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Composite Materials
(See article, p. 4)

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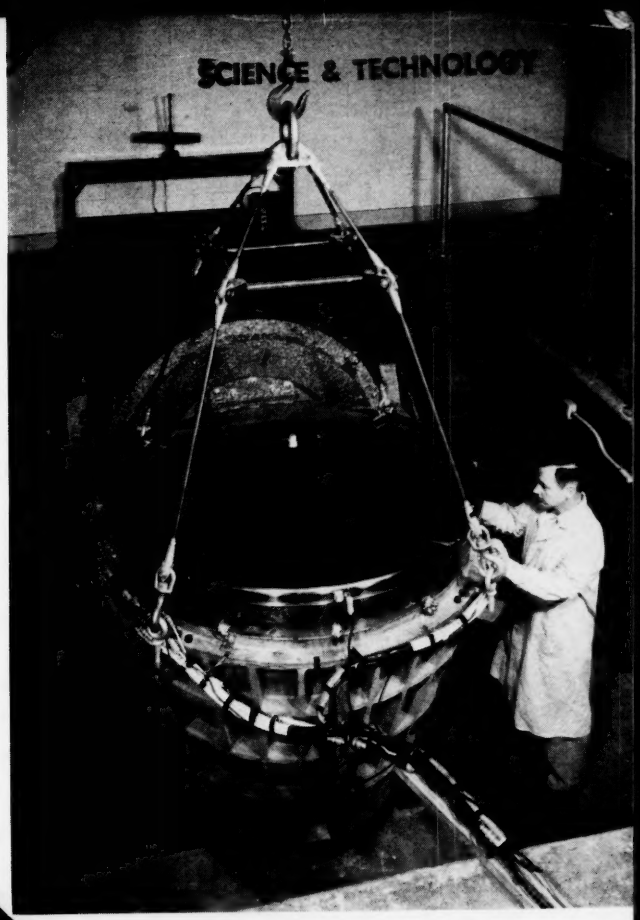

METALS REVIEW

The News Digest Magazine

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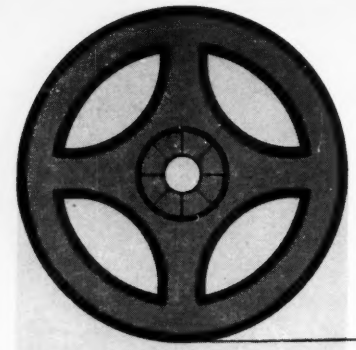

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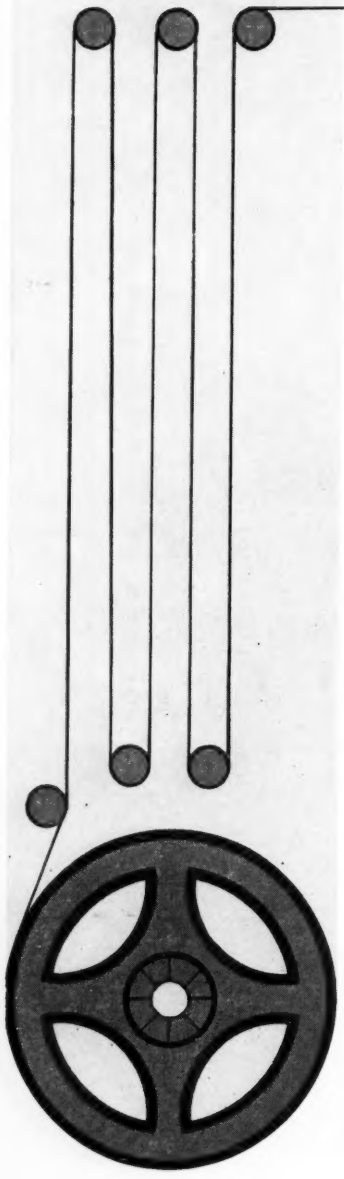

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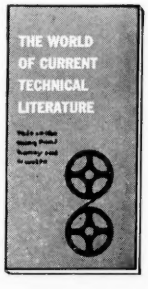

November, 1960 Vol. XXXIII, No. 11

METALS REVIEW

The News Digest Magazine

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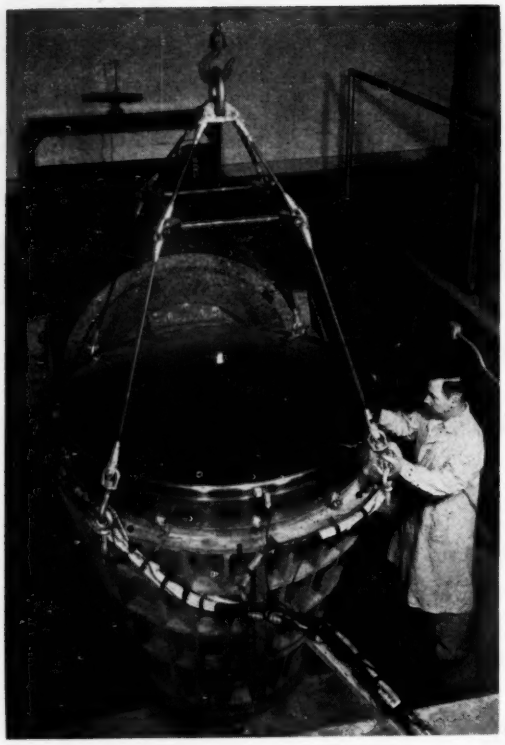


Fig. 1—Copper heat sink in process of being instrumented for vibration testing.

COMPOSITE MATERIALS FOR THERMAL PROTECTION

E. Scala*

Designers have often been forced to combine materials to meet the requirements of thermal shock, light weight and high reliability. Supersonic missiles and aircraft continually force engineering beyond current materials capability, often with marginal safety factors, or worse, with calculated uncertainties requiring extensive and expensive prototype testing. Rocket nozzles, manned re-entry vehicles, and ICBM heat shields are good examples of the utilization of the optimum properties of metals, plastics and ceramics as composites.

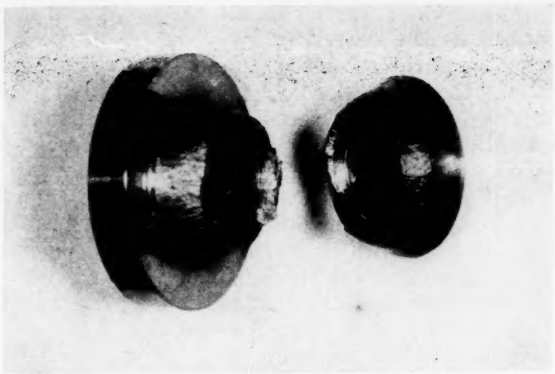
THE HEAT SINK

A copper heat sink for an ICBM (Fig. 1) is essentially a composite of metals—a highly reliable heat shield capable of withstanding the launch and re-entry loads. The size, weight and varying design requirements called also for a versatile fabrication process. One method, the electroforming of copper, permitted the production of large diameter shapes with varying thicknesses. The procedure was developed to permit a build-up of several inches of a high-purity, high-conductivity copper with good mechanical properties and an excellent thermal and mechanical bond to the supporting structural shell, a Type 316 stainless steel forging. For improved efficiency, the stainless steel shell was utilized as part of the heat sink and a bond free of defects was required for optimum heat transfer characteristics. Any separation at the bond would result in excessively high temperatures in the copper. Brazing such a large area, while possible, presented serious drawbacks. The quality of the electroformed structure is evident in Fig. 2, a special bond-tensile test illustrating copper ductility and the high bond strength. The electroformed copper, with a 1200°F. anneal, would have a room temperature tensile strength of 29,000 psi. and an 80% reduction in area.

Electroformed nickel over the copper permitted optimizing thermally with further weight savings, taking advantage of the higher melting point and oxidation resistance with good reflectivity. The composite of nickel-copper-stainless shown in Fig. 3, with varying thicknesses as required, was a combination which lent itself well to electroforming. It utilized the high thermal diffusivity of the copper, the high-temperature strength of the stainless steel base and could take the re-entry loads with a minimum shape change as the blunt nose smashed into the upper atmosphere with extremely high deceleration forces. Monocoque structures were used where

*Avco Corp., Research and Development Div., Wilmington, Mass. *(Paper presented at A.S.M. Southwestern Metal Congress, Dallas, Tex., May 9, 1960)*

Fig. 2—Tensile tests of a special bond illustrate ductility of the copper and high strength of the bond.



possible, such as the stainless steel afterbody in Fig. 4 and the beryllium afterbody in Fig. 5.

Concurrent with the design and fabrication of the heat sink composites were the nondestructive testing problems. Special ultrasonic tests were developed to detect flaws in the heavy electroformed metals and at the bonds. Augmented by radiography, mechanical testing and sampling techniques, a high degree of quality control was established.

ABLATIVE DESIGNS

With higher heat fluxes, the heat sink concept was no longer adequate and the more complex techniques of transpiration, film cooling or ablation were required. Ablation has proven to be the simplest to utilize, although we certainly do not completely understand material behavior. Ablation as a thermal protection device is similar to that of the brake lining. One could, therefore, list many sacrificial materials which can protect a structure from intensive surface heating.

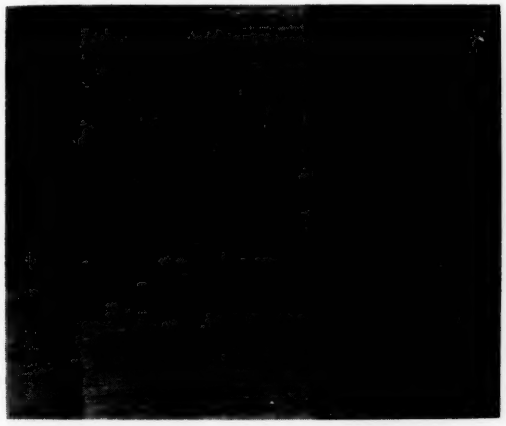


Fig. 3—Cross-section of composite of nickel-copper-stainless steel.

Convective heating at the boundary layer is the primary mechanism involved in aerodynamic heating, as distinct from conductive and radiative heating. The tests employed to evaluate materials must, therefore, simulate ascent heating or re-entry heating. The air stabilized arc plasma has been developed as the ground testing device which most closely simulates the thermal environment, that is, the proper gas enthalpy and chemistry can be employed. The arcs are subsonic and usually operated at one atmosphere pressure and as stagnation point tests involving laminar gas flow at the boundary layer. The possible effects of pressure, surface shear forces,

TABLE OF PROPERTIES

	m.p. °F.	b.p. °F.	H_M Btu/lb.	H_b Btu/lb.	H_d Btu/lb.
C	—	6700	—	12,100	—
BeO	4620	7700	3400	13,400	—
MgO	5070	d 5715	1920	—	10,090
SiO_2	3140 (1)	d 5070	— (1)	— (2)	6,650
SiC	— (3)	d 4892	— (3)	— (2)	7,050
Teflon					1,300 (4)
H_2O	32	212	144 (5)	1,306 (6)	28,440 (7)

Enthalpies from 100°F. through the melting point (H_M); through the boiling point (H_b); and including decomposition (H_d).

(1) The melting point for the crystalline state; fused silica is a highly viscous liquid and, as such, has no definite melting point.
(2) Both SiO_2 and SiC do not really boil but form a gas phase by decomposition.
(3) Silicon carbide decomposes before it melts.
(4) Experimentally determined by AVCO RAD.
(5) Latent heat of melting only.
(6) Ice at 32°F. to steam at 212°F.
(7) At 1 atm. pressure and 8540°F.

turbulence and geometry must not be ignored in measuring the "effective" heat capacity in Btu/lb. Much of the published data on ablative values must, therefore, be looked at critically for thermodynamic and aerodynamic factors before accepting the values from torch or arc tests.

Water, up to and including decomposition, is potentially the best material but keeping it around long enough to do some good is a problem. Materials which go through a liquid phase or char present this problem in that turbulent aerodynamic conditions and mechanical degradation combine to decrease the efficiency and predictability of the heat shield.

It is important to utilize the heat of vaporization and decomposition. Examples of the potentials of some ceramics are listed in the Table of Properties (p. 5).

Beryllium oxide and magnesium oxide are of considerable interest but a good deal more about their high-temperature chemical and thermal properties must be known. The magnesium oxide, for example, is believed to sublime with some decomposition occurring simultaneously. The effect of pressure, however, is unknown and if an increase of a few atmospheres suppresses decomposition and permits melting, its potential heat capacity may not be realized when the liquid flows away under surface shear forces.

The products of decomposition must also be known with a greater degree of certainty, since the extent of formation of monomolecular species is the assumption usually made in calculating the maximum enthalpies.

The thermal conductivity properties are also of prime importance. A high thermal conductivity such as magnesium oxide or graphite can result in too low a surface temperature and too high a backwall temperature. In this way, the difference between the boundary layer gas temperatures and the surface remains high, increasing the heat input while the backup structure is insufficiently insulated. The heat of vaporization can also never be realized, resulting in the ceramic being used as a heat sink. In fact, the heat flux must be extremely high to profitably utilize the high-melting point ceramics such as beryllium oxide, magnesium oxide and graphite, even with low conductivity induced by special preparation techniques.

Ceramics and graphite, therefore, present excellent potentials—except for the thermal shock and mechanical brittleness problems. For practical devices, many of the controlling factors become the environmental and ground handling problems encountered before the missile is ever launched.

Rocket engines employing graphite vanes and throats have been faced with the problem of using a brittle material and the inherent possibility of catastrophic failures. The increasingly severe requirements to survive high gas enthalpies, velocities and pressures with excellent reliability call for a superior combination of high-temperature linings, insulations and structural shells. The designers of furnaces have dealt with this problem area for many years, but the new applications call for higher tolerances, minimum weight and much lighter wall thicknesses.

Heat fluxes of five to ten million Btu/ft^2/sec. must be withstood, and with no changes in throat area. In order to utilize the highest melting points, the brittle ceramics, metals and graphites are being employed, supported as coatings on ductile metal shells, by adhesive bonding, by pre-stressing to take advantage of the high com-

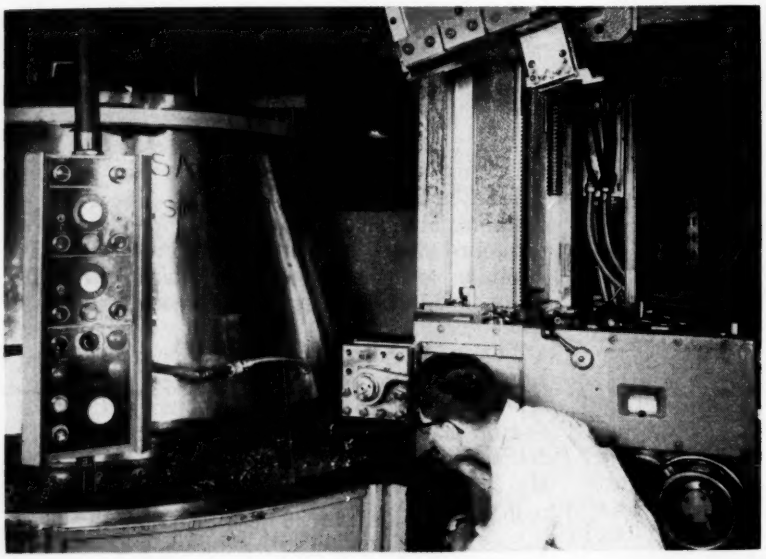
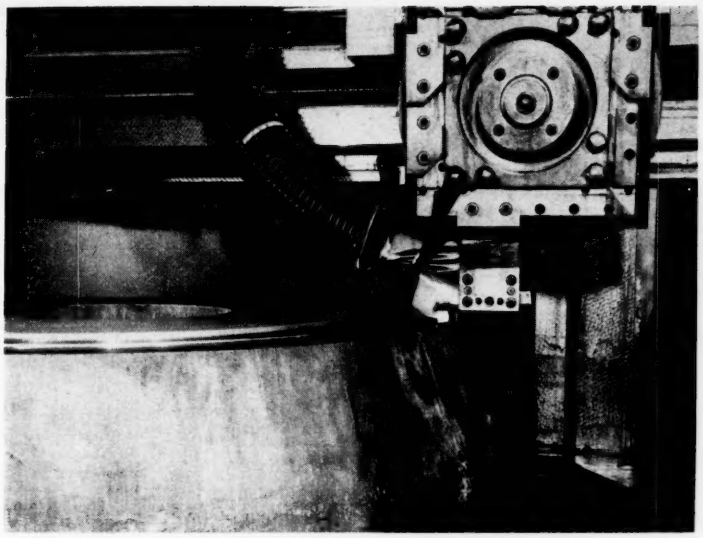


Fig. 4—Stainless steel afterbody during machining.

Fig. 5—Machining of beryllium afterbody billet.



pressive strengths, as laminates or agglomerates or by incorporating reinforcements.

The design of brittle parts, supported by or bonded to high-strength back-up structures is a brute force approach. One must be content with large-scale testing and in large enough numbers to give a statistical picture of the reliability. It is extremely difficult to predict the "safe" design with high reliability when forced to employ a brittle material.

CERAMICS AS HEAT SHIELDS

In an attempt to utilize ceramics as heat shields, the immediate problem to the designer is structural reliability—particularly thermal shock. Of the many techniques of metal reinforcement and cermets, the one found most useful was a composite of metal honeycomb and ceramic. Various test samples are shown in Fig. 6 after exposure to an air stabilized arc plasma, and the resistance to thermal shock is evident. There are, in addition, some peculiar mechanical features which can be of value structurally. Fig. 7 illustrates a sample after a bend test. Although the details of mechanical properties are classified, the compressive and tensile properties of the ceramics are improved upon, in that the scatter of rupture data is significantly reduced. This permits design with adequate safety factors and reasonable weights and thicknesses.

Various methods of fabrication have been employed, such as slip casting, sintering, hot pressing and hot isostatic pressing. One of the problems is the fabrication of the high-melting point metal honeycombs. The stainless steel and nickel-base alloys presented only minor problems. Recent developments have permitted the use of all the refractory metals, the most useful of which is tungsten. The fabrication requires the forming of the refractory metal honeycombs into geometric shapes, such as cylinders, cones, frusta and the like of sizes varying from an inside diameter of ½ in. up to several feet. This has been possible with the improved qualities of 1-3 mil refractory alloy strip that has become increasingly available in the last two years. More or less standard welding and braze welding have been employed for the node joining. The prime purpose of the honeycomb is to reduce the thermal shock and spalling in the ceramic, rather

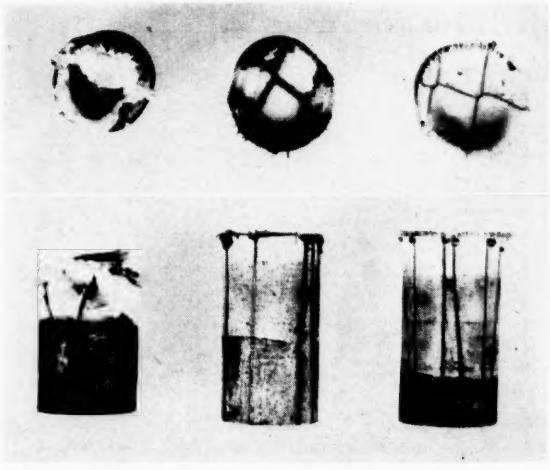


Fig. 6—Comparison of unreinforced ceramic and honeycomb-reinforced ceramic after exposure to an air stabilized arc.

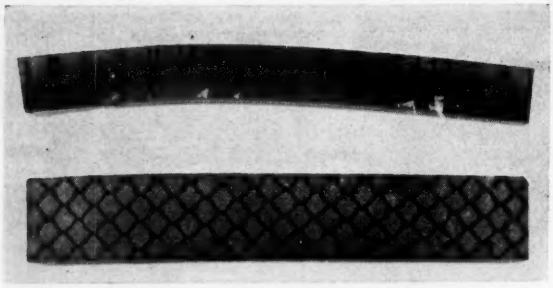


Fig. 7—Bend test of honeycomb-reinforced ceramic.

than as a pure load-carrying member, and the joining problem is somewhat critical, particularly with the subsequent forming operations.

The chemical compatibility of the metal honeycomb with the ceramic or intermetallic compound is also a problem. Both the high temperatures in fabrication and in the end application as heat shield devices must be taken into account. The metal structure must not be embrittled and there must be a minimum of interaction with the environment, which usually differs for the various applications such as a furnace lining, a rocket nozzle or a re-entry vehicle heat shield. The honeycomb-ceramic has been found very useful where a high-melting point refractory is required under high thermal shock conditions.

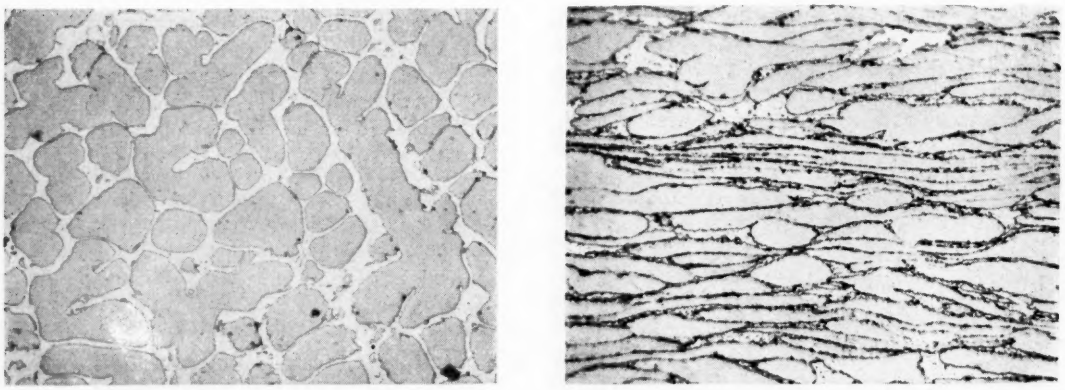
Another means of improving the thermal shock and mechanical properties is by the presence of a ductile interphase on almost a microscopic scale. Ceramic-metal composites produced by infiltrating a lower melting point metal into the sintered skeleton of a refractory accomplished somewhat the same purpose as the honeycomb ceramic, in effect carrying the cell down to the grain size.

The technique of a ductile second phase has also been employed with brittle metals. A sample of beryllium with approximately 20% silver has been cold rolled 83% and is shown in Fig. 8. An interesting point here is the evidence of deformation of the beryllium-rich phase which has undergone plastic deformation under essentially hydrostatic conditions within the more ductile silver-rich matrix. The same method can be employed with the brittle refractory metals such as tungsten, and is a common practice in the fabrication of elements for electronics and electrical contacts. These techniques are also old to the tool industry wherein the tool bits require a high resistance to mechanical stress and thermal shock.

REINFORCED PLASTICS

As mentioned earlier, the short-time, high heat flux conditions require materials with good thermal shock resistance and low thermal conductivity. Many organics and reinforced plastics offer an efficient solution of their added advantage of low density, plus ease and flexibility of fabrication. In reinforced plastics, the ceramics are incorporated as fibers, flakes or powder wherein the resins add a matrix of low density and low thermal conductivity. The ceramics add strength as well as fracture resistance. For thermal protection, these combinations are ideal since with extremely high heat fluxes, the pyrolysis and carburization of the organic and the vapor pressure of the ceramic can be utilized. These characteristics are favorable to applications where the heat fluxes are high and the mass loss and changes in dimensions are not extremely critical.

Fig. 8—Beryllium—18.6 a/o silver alloy, as cast (left), and reduced 83% by cold rolling.



The behavior of the organics under ablating conditions is quite complex and not understood, although there are numerous theories. The additives can change the mechanism of decomposition of the phenolics or epoxies usually employed. The behavior can vary from a Teflon-type unzipping leaving no residue, to a charring phenolic leaving practically a graphite coating.

The low elastic modulus and very low mechanical strength at temperatures of 200 to 500° F. require metal backup structures for the plastics and preclude their high-temperature use for periods longer than a few minutes. The latter is determined by the combination of thermal diffusivity, ablation rates and the gradual degradation of the organics, all occurring simultaneously and interrelated. Nevertheless, the organics have solved many of the materials problems exceeding the capabilities of heat sink and hot structure designs.

CONCLUSION

The future problems in supersonic aircraft and space vehicles are best summarized by the chart in Fig. 9. Hot structures, calling for high-temperature, high-strength characteristics, are dependent on metals and ceramics and, of course, graphites. But with heat fluxes of over 1000 Btu/ft²/sec., devices must be resorted to which permit insulating by ablation or film cooling, high reflectivity and low conductivity. Pyrolytic graphite is a potential that may combine many characteristics but it is still essentially a brittle structure at temperatures below 1000° C.

One cannot, however, use the chart to divine specific materials or techniques, because of numerous requirements not amenable to plotting such as optical or electrical specifications, strength, impact resistance and chemical erosion.

The most reliable, versatile materials from which to build structures for heat phases less than 10 min. are the plastic-base materials, wherein they are destroyed in use. Metals and ceramics as composites could be employed, although they may not be the optimum when balancing reliability and cost.

The metal-base structures must be employed for the long time-low heat flux regions. The higher temperature requirements force the use of the refractory metals with many attempts and schemes to use ceramics. As the experience with the design of brittle structures improves, we can squeeze a bit more out of the available materials.

For maximum reliability, metals will be extended to their limits in initial designs, yielding to the brittle structures as our confidence and experience increase, as has been the case with ablating plastics. There are, however, increasing engineering requirements wherein the highest of available melting points are not good enough.

At extreme heat fluxes and for long periods (relative to thermal diffusion rates) the recourse is to transpiration, forced cooling and boundary control devices which can affect the rates of heat transfer to a wall.

The electromagnetic control of ionized gases and boundary layer control are two approaches for avoiding the problems of high surface heat transfer. Concurrently, the exploration for new higher melting point compounds, such as the graphalloys, presents interesting possibilities. But the latter will involve small increments that may possibly keep up with the creeping higher flame temperatures of the chemical rocket engines. Radical approaches in high-temperature, high-strength materials are needed, but many of the problems will be solved by employing propulsion devices and re-entry techniques which avoid the high temperatures.

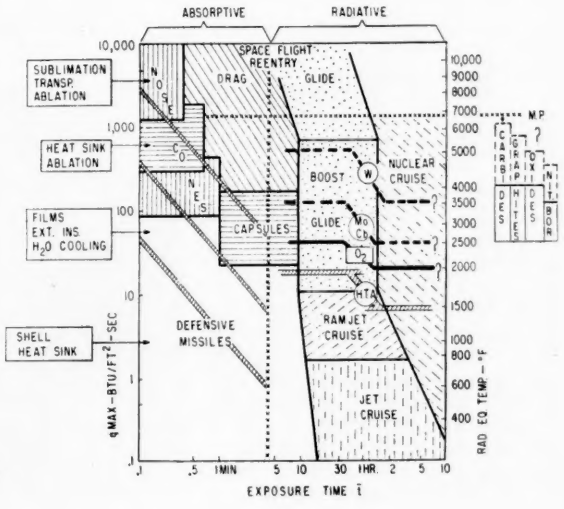


Fig. 9—Dependence of flight attainments on materials developments. (Courtesy W. S. Pellini).

METALS

Lower Cost Iron Process Revealed

Details of an ironmaking process requiring about one-third the investment per ton and capable of matching or bettering production costs of conventional high-tonnage processes were revealed in Cleveland recently by McDowell Co., Inc.

Called the Dwight-Lloyd McWane Process, it has been in continuing development for almost 12 years. Since 1956, the work has been conducted at McDowell's Cleveland research facilities where extensive operating plant studies have been undertaken.

Instead of the usual blast furnace and coke plant, the D-LM Process is based on a combination of sintering machine and electric furnace, plus optional grinding and pelletizing equipment. It is expected to be of primary interest to companies with iron needs in the range of 500 tons per day, but can be scaled up economically to greater capacities.

D-LM lends itself to the use of inexpensive raw materials, such as ore and limestone screenings, and to noncoking quality coal. In operation, fine iron ore is mixed with coal fines and limestone, pelletized and fed to the sintering machine, where partial reduction is accomplished. The sintering machine discharges self-fluxing, self-reducing pellets at approximately 1500° F. to the electric furnace for final smelting.

"Based on economics developed in the company's demonstration plant studies", says Robert C. McDowell, president, "a single-unit D-LM plant producing about 500 tons of pig iron per day will cost between $6,000,000 and $7,000,000 to build. This represents a capital cost of between $35-45 per net ton. By comparison, a modern blast furnace and coke plant requires an investment of approximately $90 per net ton of annual capacity".

Production costs of the D-LM Process will depend on the cost of electric power for smelting and on the delivered costs of iron ore, coal and limestone. Pilot plant studies show that in the Lake Erie region, where electrical power costs approximately 8 mills per kwh., D-LM iron can be produced for about $47 per ton. In the St. Lawrence River area, with power at half the cost, a net ton of iron would cost less than $39 to produce. These figures, says the company, include all raw materials costs and labor, indirect, maintenance, payroll and fixed costs, as well as an allowance for sales and distribution charges.

Product metallurgy can be controlled closely because of fast reaction times and the flexibility of the operation. Basic hot metal, pig iron, white cast iron, gray cast iron and silvery pig iron can all be produced with reasonable facility, and the process lends itself well to ferroalloy production.

Predicts End of Openhearth Construction

The electrical industry will benefit by future changes in steelmaking processes, a steel leader recently told a General Electric Co. audience.

More use of the electric furnace and basic oxygen processes to make steel will rely heavily on electricity, Edward J. Hanley, president of Allegheny Ludlum Steel Corp., said.

Mr. Hanley forecast that the last

ALUMINUM FUEL PIPING SYSTEM—*The largest diameter seamless aluminum pipe produced in this country now forms the underground fueling system for jet aircraft at Lemoore Naval Air Station, Calif. Pipe was produced by Alcoa in 35-ft. lengths, with ½-in. wall thickness, on a 14,000-ton extrusion press at the company's Lafayette (Ind.) works. Joining was accomplished by one welder and a helper using the inert gas-shielded consumable electrode method. Pipe coating, turned back to facilitate welding, was applied according to Navy specifications developed for stainless steel pipe originally considered for the application.*

big openhearth shop has been built in the American steel industry. He said "electric furnace capacity will grow steadily and basic oxygen is due for spectacular growth in the next decade".

Mr. Hanley spoke to about 200 G-E management members at the fifth in a series of programs, "What's Behind the Growth of Electric Utilities".

The basic oxygen process was not in existence in the U.S. ten years ago, Mr. Hanley pointed out. "The total present capacity of 4.2 million tons (by that process) has been placed in operation only within the last few years". He also said electric furnace tonnage has increased 58% in the last ten years.

"I think it can be safely said that, in view of the economies found in the basic oxygen process, the last big openhearth shop has been built in the American industry".

René 41 Produced in Wire Form

René 41 vacuum-melted, nickel-base alloy is being used by the National-Standard Co. for springs to be operated at temperatures to 1800° F. (approximately the melting point of copper). Typical applications include missiles, electronics, rockets and nuclear equipment.

René 41 is available in a range of conditions from annealed to spring tempers in diameters from 0.200-0.004 in. Tensile strength in spring temper ranges from 250,000 to 280,000 psi. Modulus of elasticity ranges from 31.6 million psi. at room temperature to 20 million psi. at 1700° F.

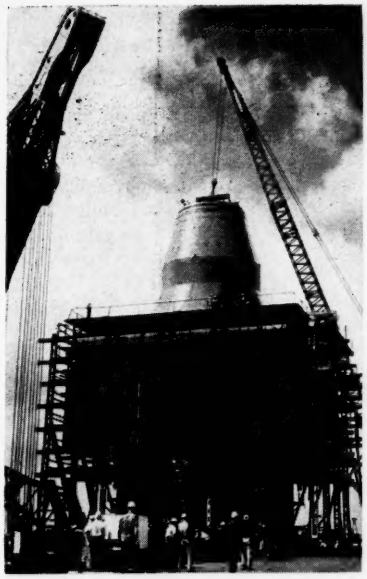
Introduce Differentially Coated Galvanized Sheet

A new differentially zinc-coated sheet, featuring a corrosion-resistant, hot dip zinc coating on one surface and a smooth spangle-free finish providing an excellent base for high lustre body finishes on the other, has been introduced by Armco Steel Corp.

Designated Armco Zincgrip DC, the new sheet combines, for the first time, paintability with good spot welding characteristics while providing corrosion protection where it is needed.

Of particular importance to truck and auto body builders is the compatibility of Zincgrip DC with phosphate paint bonding systems currently used in the automotive industry to prepare the surface of cold rolled steel. Body assemblies including both cold rolled steel and Zincgrip DC can be treated for painting at one time. Previously, zinc-coated parts required special preparation for painting.

By coating only one surface with standard weight of zinc, Armco sharply improved the welding characteristics of the sheet. Twice the number of spot welds possible on regular galvanized sheet can be made on Zincgrip DC before welding tips applied to the nonspangled side have to be redressed.



ENTERPRISE CAPPED IN ALUMINUM—*The giant aluminum dome being lowered into place on the U.S.S. Enterprise is higher than a four-story building. More than 47,000 lb. of aluminum plate and shapes are used in the dome. According to Reynolds Metals Co., the Enterprise, when completed, will have used more aluminum than any other naval vessel.*

Record Sized Molybdenum Sheet Is Produced

What is claimed to be the world's largest sheet of molybdenum is now available on a mill order basis from Universal-Cyclops Steel Corp. The sheet size of 48 in. x 105 in. long and 0.060 in. thick makes possible the fabrication of aircraft and missile parts with considerably fewer joints.

NONMETALLIC MATERIALS

Super-Graphites Successful in Rocket Motor Trials

A revolutionary hot working process is being used to produce a recrystallized graphite with approximately two to three times the high-temperature strength of conventional graphites. According to National Carbon Co., which developed a series of the graphites, the unique material has usable strength at temperatures as high as 5500° F.

Using techniques more akin to metallurgical than ceramic technology, the process creates a crystal alignment and internal grain structure that provide required high strength and an exceptionally low creep rate. The polycrystalline nature of the material retains the advantages of machinability and thermal shock resistance while attaining strengths and densities comparable to pyrolytic graphite.

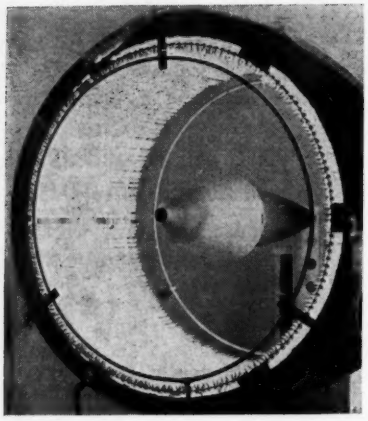
In tests of rocket nozzle inserts made of recrystallized graphite, all conditions affecting erosion of the parts were widely varied. Inserts made of the new material are reported to be equal to, and in some instances considerably superior to, other high-temperature materials, including tungsten and pyrolytic graphite.

Details of the recrystallization process have been classified and all current production is earmarked for military applications.

National Carbon reports there are no technological limitations to the size in which recrystallized graphite can be produced. Cylinders as large as 8 in. in diameter and 10 in. long have been made and 12 x 14 in. pieces are anticipated in the immediate future.

The recrystallizing process achieves a more uniform and compact graphite structure. Through close control, grain orientation can be varied to produce a wide range of materials, with each grade having its own peculiar set of properties.

Conventional artificial graphites range in density up to approximately 1.85 grams per cubic centimeter. Only natural graphite and pyrolytic graphite have had densities approaching the theoretical value of



HEATING WITH LIGHT—*"Thermal barrier" temperatures are simulated here in this nose cone test at the National Aeronautical and Space Administration's Langley Research Center in Virginia. Heat produced by 225 2500-watt tubular General Electric quartz infrared lamps in the cylindrical radiator reaches 3100° F., about a third as hot as the surface of the sun. Such tests facilitate the nation's efforts to overcome the re-entry problems faced in rocket, missile and space-vehicle programs.*

2.26 grams per cubic centimeter. This density range is now attained in the super graphites in massive form.

Room temperature flexural strength of recrystallized graphite is approximately 6000 psi. or more, as compared to 3000 to 3500 psi. for the best conventional graphite. The strength increases at higher temperatures until at 4500° F. it is approximately double the room-temperature value.

Ceramics, Metals Combined in High-temperature Material

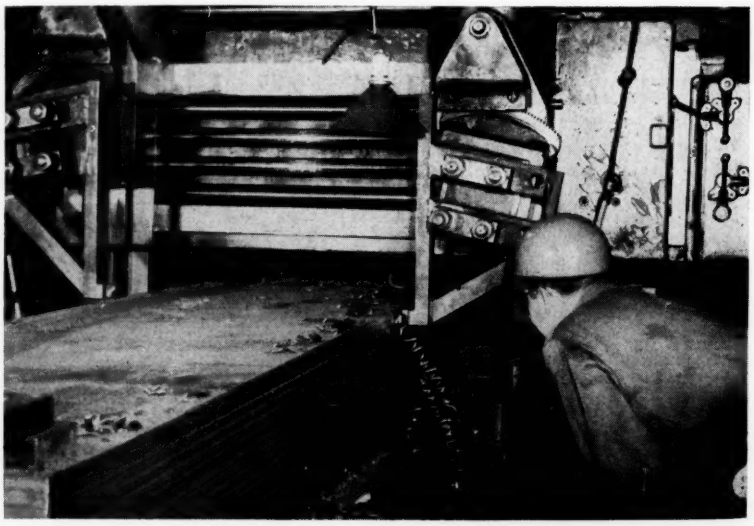
Pfaudler Division of Pfaudler Permutit Inc. has introduced a revolutionary new material of construction which is said to be of great potential interest to manufacturers engaged in chemical, nuclear and space technology. Called Nucerite by Pfaudler, the material is a ceramic metal composite consisting of a unique crystallized glass structure physically and chemically bonded to a structural metal. The new material possesses exceptional resistance to high-temperature corrosive vapors (1200 to 1400° F.) which would destroy most metals in a matter of a few minutes. It is expected that even this temperature range will be exceeded by several hundred degrees. In addition, compared to corrosion resistant ceramic materials which might be considered for use in similar applications, Nucerite represents a significant advance in its collective properties of mechanical strength, thermal shock resistance, abrasion resistance, heat conductance and high-temperature stability, according to the manufacturer.

Nucerite is permanently bonded to steel or to other heat resistant materials such as Inconel or Hastelloy. Because of the nature of some anticipated higher temperature applications, to 2500° F., it is also probable that certain of the refractory metals such as tantalum, columbium and molybdenum —which maintain strength at elevated temperatures—will also serve as base metals.

In commenting on the new development, Mercer Brugler, chairman of the Board stated: "Although we have successfully fabricated and tested such common items of process equipment as small reaction vessels and heat exchanger parts, it is important to emphasize that these results were obtained and confirmed in carefully controlled laboratory and field tests. It will still take considerable additional work to transform Nucerite from the developmental stage to full-scale production. At present an extended evaluation period of field testing in the U.S.A. is planned. This period then, will be followed by the establishment of production facilities in all of Pfaudler's domestic and foreign plants.

In the laboratory, Nucerite has successfully undergone the following tests: Tensile Strength—The ceramic component in rod form withstood more stress without permanent deformation than did mild steel. Impact Strength—Ceramic component withstood 10.8 ft-lb. of point impact force, or approximately 18 times that needed to shatter safety plate glass. Thermal shock—300-400% increase in resistance to damage by thermal shock over existing glassed metals. Abrasion—400% more resistant to abrasion than laboratory glass. Heat Transfer—6-13 times better than other ceramic materials that would be used in high-temperature corrosive services. High-Temperature Stability—Has protected molybdenum from oxidation at 1600° F. in an oxy-acetylene flame.

STACK-UP FOR AN ATOM-SMASHER—*This stack of 15 steel plates, here being edge-machined at Lukens Steel Co., Coatesville, Pa., is part of a 5,500-ton order destined to become the heart of the Argonne National Laboratory's giant new "atomic race track"—the Zero Gradient Proton Synchrotron. Nearly 40,000 plates are being furnished by Lukens to Baldwin-Lima Hamilton Corp., Philadelphia, who will fabricate the magnetic ring for the synchrotron.*



INDUSTRIAL HEATING

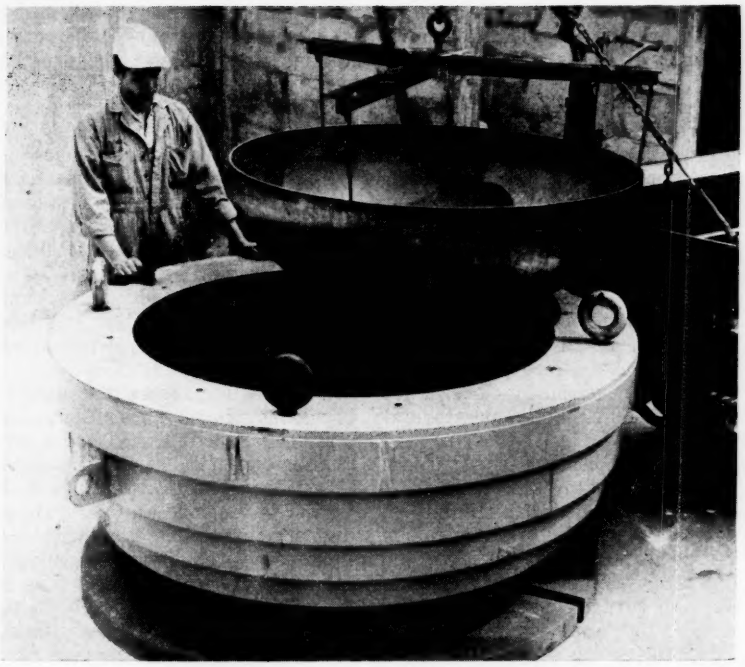
Portable Unit Measures Moisture in Gas Atmospheres

Accurate measurement and continuous monitoring of trace quantities of oxygen and moisture is special gas atmospheres can be performed with a new Portable Furnace Atmosphere Analyzer introduced by the Chemical Division of Engelhard Industries, Inc. The analyzer is designed particularly for producers of the so-called "exotic" metals, semiconductor materials and various electronic devices, all of which are frequently manufactured, processed or stored in protective atmospheres.

Mounted on a portable wagon, the analyzer essentially consists of an Engelhard Supersensitive Deoxo Indicator for measuring oxygen in hydrogen and forming gases, and for measuring either oxygen or hydrogen in helium, nitrogen, and argon; two electrolytic hygrometers, one for measuring the moisture content of helium, nitrogen and argon, and the other measuring the moisture in hydrogen and forming gases; circular chart recorders for maintaining a continuous record of oxygen and water vapor levels; and various associated pumps, pressure regulators, solenoid valves, filters, electrical components and other necessary equipment.

The analyzer can be used to continuously monitor oxygen and water vapor concentrations, giving very rapid response to changes, or it may be used for periodic checks. Particularly valuable in trouble shooting or in the start-up of new or newly repaired or modified facilities is the fact that a sampling probe can be moved from point to point within a furnace, greatly facilitating the task of finding leaks.

Principal applications of the Engelhard analyzer are in heat treating and crystal growing furnaces, storage dry boxes and assembly facilities used in the manufacture of semiconductor materials, transistors and other electronic devices in which the pick-up of even minute quantities of undesirable impurities may have serious effects on performance and useful life. Certain other processes require moist oxidizing atmospheres to produce properly oxidized metals for glass-to-metal seals and here again knowledge of the precise gas composition is desirable for optimum quality control. In addition, the analyzer will prove useful in the processing of various metals, such as titanium and zirconium, for applications in field other than electronics.



EXPLOSIVE FORMING SHAPES POLARIS HEAD—*Heads for the Polaris missile are given their final contours through explosive forming in the Edwardsville, Ill., plant of Propellex Chemical Div., Chromalloy Corp. The 54-in. diameter heads made of high-nickel, low-chromium alloy AMS 6434 steel are first hot preformed. Dished heads of the same alloy have been successfully formed in thicknesses up to 7/8 in.*

Carbon Restoration Furnace Improves Casting Efficiency

By using one Tricarb furnace instead of two other units for carbon restoration, Arwood Corp. has been able to get 100% consistency in every casting produced, regardless of quantity.

Previously, Arwood ran batches of the same job in two furnaces in its Brooklyn plant, but this could cause variations in carbon restoration—variations which were not in line with Arwood's goal of consistency in every aspect of its castings.

Now, an entire job can usually be run in one load in the Tricarb, or, if reloading is necessary, the exact temperature conditions and atmosphere can be reproduced with no difficulty. This method is 100% effective, so that Arwood has had no part rejections due to decarbonization.

The casting manufacturer also uses the furnace for hardening and case carburizing. This is done by simply resetting the temperature and control instruments for each process.

Stainless steels of the 400 series are hardened in the Tricarb furnace. By substituting a high dewpoint endo-gas atmosphere for the carbonaceous atmosphere in the furnace, Arwood hardens the stainless castings at 1875-1900° F. It then oil-quenches them without exposure to air. On 410 stainless, a consistent hardness of 42-46 Rc is obtained and the parts are clean and scale free.

Laboratory Vacuum Facilities for Outside Groups

Metalworking firms who would like to explore the applicability of vacuum heat treating, brazing, high-temperature sintering or precision casting to their production processes before making a commitment for capital investment will now be able to do so at nominal cost in special laboratory facilities

which have recently been established by the vacuum metallurgical department of F. J. Stokes Corp. at the company's headquarters in Philadelphia.

The facilities, which are being made available at a modest scale of laboratory service fees, include:

A cold wall vacuum heat treating furnace, designed to operate at temperatures up to 2200° C. and with a hot-zone 3½ in. in diameter and 6½ in. deep.

A precision casting vacuum furnace, with an ultimate capacity of 17 lb. (steel measure), particularly suited for development work in new processes and high-temperature alloys.

A vacuum heat treating furnace, where temperatures up to 1850° F. can be maintained within a uniform temperature zone, 10 in. in diameter and 10 in. high.

These three standard-design vacuum furnaces supplement pilot-scale equipment in the Stokes laboratories for experimental evaluation of vacuum metallizing techniques, vacuum drying cycles and powder metal pressing.

Helium-Cooled Vacuum Melting Furnace Casts Reactive and Refractory Metals

Development of the first large helium-cooled vacuum arc melting furnace intended for recovery of titanium scrap has been announced by National Research Corp.

The new furnace, also suited for handling other reactive and refractory metals, provides improved operating safety for melting and casting such metals and combines unique features of skull melting by permanent electrode with vacuum melting by consumable electrode.

During the first ten successful pilot runs, the furnace has proven out several unusual design features, including its helium gas cooling system which replaces the more conventional and more hazardous water cooling normally employed. Titanium, among other reactive metals, reacts explosively with water in the event of a mechanical failure inside the furnace jacket, such as a ruptured pipe.

The furnace was developed by NRC under contract for the General Services Administration. Single pours of titanium up to 550 lbs. have been demonstrated and company engineers are confident, based on data obtained, that 800-lb. pours can be achieved with the present unit.

Other reactive and refractory metals which appear promising for alloying and casting development in the NRC furnace include columbium, tantalum, molybdenum and tungsten. Another advantage of the process inherent in skull melting and not achievable with cold mold techniques, is the ability to pour from the skull into either ingot or shape castings as desired, using suitable molds.

Proposed for future research using the new furnace are systems for centrifugal casting in either a vertical or horizontal casting machine. It is believed vertical castings with typical dimensions up to 2½ ft. in diameter by 1½ ft. high with 3½ in. average wall thickness could be produced. Horizontal castings up to 5½ ft. in length are possible using suitable external equipment coupled to the furnace at the present door flange.

Corrosion Resistance of Stainless Steel Increased by Annealing

The corrosion resistance of type 430 stainless steel—used extensively in automotive chrome trim—can be greatly increased during annealing in a newly developed, vertical bright annealing furnace, according to tests at General Electric's Industrial Heating Dept., Shelbyville, Ind.

Steel manufacturers have been plagued for some time with widely varying percentages of type 430 stainless that will pass the auto industry's acid test for chrome trim applications. While some batches of steel produced may be universally accepted, other batches will fail the test.

In conducting the tests, the G-E engineers determined that if the final anneal is performed in a high-purity atmosphere, such as that used in the new vertical bright annealing furnace, there is no depletion of surface chrome.

Steel previously unacceptable may be "upgraded" when put through a final anneal in this new furnace, according to the G-E engineers. Use of the new furnace results in the diffusion of chrome to the surface of the strip, rendering increased corrosion resistance.

Largest Vacuum Furnace on Order

One of the largest vacuum furnaces of its type ever built is under construction for the research laboratories of General Electric Co. by General Vacuum Corp., East Boston, Mass. The furnace is to be used for processing space-age materials under controlled ultra-pure vacuum conditions. The furnace will provide temperatures above 4500° F. in a zone over 1 ft. in diameter and 2 ft. high. The equipment will permit the attainment of a vacuum equivalent to an altitude in excess of 100 miles above the earth's surface.

An objective of the new, large furnace is to permit metallurgical operations with tungsten, tantalum and other high-temperature materials on a production scale.

Welding & Joining

Welding Process Adapted to Aluminum

As a result of a 2-year study program, the MIG arc spot welding process can now be used extensively in the fabrication of aluminum products. The announcement was made by Olin Mathieson Chemical Corp., in whose metallurgical research laboratories the study program was conducted.

Where applicable, the company indicates, use of the process will result in more rapid production, substantial labor and equipment savings and improved product appearance as compared with those possible with riveting or conventional resistance spot welding.

Originally developed for steel joining, MIG spot welding has not previously been extensively used in joining aluminum because of difficulties in obtaining consistent results. It is a form of consumable electrode, inert gas shielded, metal arc welding.

In using the process, welds can be made without distortion in the base metal. Welds are said to have excellent fatigue properties and corrosion resistance is equal to that of the aluminum alloys joined.

Currently, the MIG process cannot be used with the high-strength,

heat-treatable aluminum alloys in the 2000 and 7000 series. Too, the method is not suitable to material less than 0.030-in. thick. When materials of unequal thickness are being joined, the thinner material must be welded to the thicker.

Technical details of the process, as well as test data are being made available to interested manufacturers.

Arc Welding Design Contest Announced

A $25,000 Award Program for Progress in Arc Welding Design has been announced by The James F. Lincoln Arc Welding Foundation, Cleveland. The program offers cash awards for papers describing the welded steel design of either machines or structures. Separate awards will be made for machines and for structures. Rules covering the award program, which closes July 17, 1961, can be obtained from the Foundation at P. O. Box 3035, Cleveland 17.

Welding Speed and quality Controlled by Electronics

An electronic scanner in the Twinsburg, Ohio, stamping plant of Chrysler Corp., automatically searches, controls, regulates, times and keeps a record on the largest automatic welding assembling line in the automatic industry.

The unit scans 24 electrical welding units 320 times per second to control firing of the units which create 860 spot welds in the rails and floor pan assembly of almost all of the corporation's cars.

Electronic control became necessary because, with the tremendous amounts of electrical power required, two giant welders fired simultaneously would create excessive voltage drop, thus seriously affecting welding quality.

In addition to permitting complete automation of the welding line, the electronic unit makes certain that every welding machine receives the same change of electricity each time it welds.

New Book on Ultrasonic Welding

A new 38-page booklet on Ultrasonic Welding has been issued by the American Welding Society. The booklet discusses fundamentals of the process, metals which can be joined by the method, welding techniques, weld characteristics, quality control, equipment and applications. Booklets can be obtained from American Welding Society, 33 West 39th Street, New York 18.

Fasteners Designed For High Strength Use

A new series of industrial fasteners have been developed to bridge the strength gap between those designed for missile and aircraft use and the standard industrial fasteners. Produced by Standard Pressed Steel Co., the fasteners have the standard configuration of socket head cap screws, but have twice the fatigue strength of their standard industrial counterparts.

The minimum static tensile strength of the new fasteners—160,000 psi.—is roughly that of the standard industrial socket screw, the endurance limit of the high fatigue series is 40,000 psi. as compared to 20,000 in the standard units.

The doubled fatigue strength is achieved by using AMS 8740 alloy steel in which the thread is rolled after heat treatment. The head-to-shank fillet is cold worked after heat treatment and special precautions are taken to prevent decarburization in the bearing surface of the head, in the shank and in the thread.

Intended uses of the new fasteners include aircraft accessories; ground support equipment; critical pumps, turbines and electrical alternators; high speed machine tools and high-impact machinery.

CLEANING & FINISHING

Nickel-Aluminum Coatings Useful at High Temperatures

The National Bureau of Standards, in a program sponsored by the Wright Air Development Center, has developed a method for producing nickel-aluminum alloy coatings capable of protecting metals from oxidation at temperatures up to 1000° C. (1832° F.). The coatings can be used to advantage on many types of aeronautical equipment. The most durable coating was obtained by plating nickel over the basis metal and then plating aluminum on the nickel at 700° C.

Although cast nickel-aluminum alloys have good corrosion-resistance to atmospheric exposure and maintain their hardness at elevated temperatures, their brittleness prevents them from being fabricated into intricately shaped components. However, by utilizing the alloy as a coating and electroplating it on more ductile metals, an effective corrosion-resistant material can be obtained.

In an attempt to find suitable plating conditions for producing a smooth, oxidation-resistant nickel-aluminum coating, the Bureau's electrodeposition laboratory studied aluminum plating baths prepared from organic solvents and fused salts.

For objects which require coatings, but which cannot withstand the high temperature necessary to operate a cryolite bath, an alternate method for plating aluminum is used. In this procedure, aluminum is deposited over the nickel at 160° C. from a fused salt bath consisting of aluminum chloride and sodium chloride and then alloyed with the nickel by heating for a few hours at 500-600° C. in air.

Steel specimens coated with the aluminum-nickel alloy were tested in the salt-spray, in outdoor exposure and in air at elevated temperatures. In air at 550 and 1000° C., the alloy coatings oxidized at one-tenth the rate of nickel coatings of comparable thickness. In the salt-spray tests, the panels plated from the cryolite bath proved to be the most durable. In fact, steel panels coated with 0.002 in. of nickel and 0.0005 in. of aluminum withstood 300 hr. in salt-spray tests before showing rust. Also, rapid thermal cycling of these panels between room temperature and 550° C. did not affect their corrosion resistance. The coatings were more resistant when the aluminum thickness was less than 50% of the total coating thickness. Corrosion studies conducted on atmospheric exposure racks correlated well with the salt-spray tests. The alloy-coated panels did not show rust at the end of one year; in comparison, nickel-plated controls rusted after four months.

The coatings provide suitable protection for steel, nickel and molybdenum, and are probably applicable to other metals. Coatings 0.002 in. thick protected steel from oxidation at 550° C. but did not afford adequate protection at 1000° C. because the iron diffused through the coating.

Space Vehicle Unit Protected by Gold Coating

"Steering jets" built for advanced space vehicles will be coated with gold to fight off cosmic bombardments, it was revealed.

The jets, called thrust controllers, manufactured by Bendix-Pacific Division of the Bendix Corp., are being plated with gold because of its reflectivity and density properties —not for glamor.

The hand-sized electro-pneumatic controllers, first developed by the company for the Discoverer satellite series, keep space vehicles from tumbling and spinning in flight by automatically providing opposing thrusts of gas, Bendix engineers explained.

The 99.8% pure gold plating is 40 one-millionths of an inch thick. This coating will reflect 95% of all energy radiation which might strike an orbiting vehicle's surface, Bendix-Pacific engineers say.

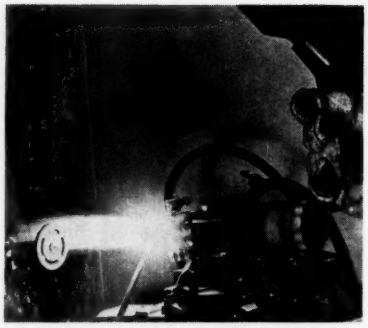
During the coating process, the controller is first sprayed with a thin coat of epoxy, a plastic which helps bond the gold to the metal device. Solid gold and the controller are then placed in a near-vacuum chamber and the gold is heated to 4712° F. At that temperature, the gold vaporizes and spreads throughout the chamber to thoroughly plate the controller. Later, the unit is baked for 30 min. in a special oven to complete the coating treatment.

Plastics Coating Available for Many Uses

Tough, armor-like coatings—their almost limitless applications ranging from automobile bumpers to sensitive recording tapes—have been developed from a new family of polyester plastic resins by the chemical division of the Goodyear Tire & Rubber Co.

The new materials are said to have exceptional resistance to abrasion, ultraviolet rays, chemicals and weather. Other advantages of the new Vitel resins include excellent adhesion, clarity, electrical properties and the ability to bind pigment.

Applications with the most promise are as clear, tinted or colored coatings for metals and such automotive hardware as bumpers and wheel covers. Other important areas of use will be as protective and decorative coatings for architectural aluminum and aluminum foil, and in wood stains, toners, primers and finishes.



PLASMA-ARC COATING—Increasing reliability of plasma-arc spraying devices has led to the development of a wide assortment of carbide, nitride, boride and oxide powders specifically for this use. Powder materials for coatings can provide corrosion resistance, high temperature resistance, erosion resistance and special electrical properties.

It is believed the resins will find wide use in hot melt adhesives and coatings. One of the resins has received approval under the pure food and drug law, making it applicable for use in the packaging industry.

The coatings can be applied by spraying, dipping, roller coating, brushing, hot melt, knife coating and most other methods of commercial importance.

High-Temperature Powders for Plasma Spraying

To take advantage of reliable commercial plasma spray units which have extended the range of high-temperature materials which can be applied as coatings, Norton Co. is now supplying a wide range of boride, carbide, nitride and oxide powders for such use.

Plasma equipment producing flame temperatures up to 15,000° F. with inert or nonreactive atmospheres, when necessary, has removed the limitations imposed by chemical flame sources so that, at least in theory, any material which does not decompose below its melting point can be sprayed.

By means of plasma equipment, these coating materials can be used on applications not previously practicable. The coating materials, in addition to their high-temperature resistance, often have the added characteristics of erosion resistance, corrosion resistance and special electrical properties.

TESTING & INSPECTION

Heat Lamps Aid Space Program

The "thermal barrier", a major obstacle to man's successful venture into space, is being overcome with the aid of a modern, sophisticated version of the common light bulb.

The role of the lamp in space research was described by William F. Hodge, of Cleveland, in a paper presented before the annual technical conference of the Illuminating Engineering Society.

Hodge, engineer for General Electric's Large Lamp Dept., described the device as a tubular, pencil-thin quartz infrared lamp, capable of producing the intense concentrations of energy required to simulate heating conditions which exist when a space vehicle enters the earth's atmosphere.

By pre-testing the heat resistance of materials, structural parts, models or whole structures of missiles, space vehicles and aircraft, the nation is able to facilitate its program in these fields, he said.

Temperatures of more than 3000° F., about one-third the temperature of the surface of the sun, are being created by closely arrayed banks of the tubular lamps in overvoltage operation.

He said the fast heating and cooling characteristics and low thermal capacity of quartz infrared lamps make them "by far the most satisfactory device" for thermal barrier simulation.

Temperatures in this work must be varied rapidly and controlled accurately to produce the same temperature conditions actual missiles would develop in passing through various regions of the earth's atmosphere, Hodge explained.

The maximum wattage a quartz lamp can withstand is determined by the melting point (about 6100° F.) of the tungsten filament. Lamps designed for 200 watts per in., now being used in thermal barrier simulation, have been operated successfully for a few seconds at 1000 watts per in.

The engineer revealed that a lamp General Electric now has under development is designed to operate at 360 watts per in. but is

capable of operating at as high as 1500 watts per in. for very short periods.

Metal Flaws Found With Portable Equipment

Two new portable units for magnetic-particle inspection have been announced by Picker X-Ray Corp. Each unit is light enough for one man to carry on the job to solve a variety of inspection problems. They are said to approach the capabilities of larger machines.

The new Picker equipment is designed to detect surface and near-surface flaws on a wide variety of metal products either in the field or in the plant. The units are especially valuable in automotive, shop, aircraft, pipeline, steel and iron, tool and die, power station, military and scientific and numerous other applications, the announcement said.

The Ferroflux unit weighs less than 30 lb., magnetizes in any direction through positioning, works on painted and nonpainted surfaces and is particularly useful for near-surface defects because the magnetic flux permeates the material. The unit, which offers an optional voltage regulator, operates on any 110-volt A-C line and has built-in silicon rectifiers for D-C. supply.

The Portaflux unit is a self-contained inspection laboratory that provides longitudinal and circular magnetization with coil and prod techniques. The portable 600-amp. (A-C.) generator and control are carried in a slender aluminum case.

Portaflux requires only 10 amp. from any 110-volt A-C. line. It has three-position intensity control and two, 7-ft. flexible, oil-resistant magnetizing cables. The unit measures 17 x 12 x 18 in., weighs 60 lb. and can be used anywhere.

Hypervelocity Wind Tunnel Creates Mach 27 Conditions

Temperatures as hot as the surface of the sun and space age speeds up to 20,000 mph. are now being created in a $1,000,000 "hot shot" wind tunnel recently built by McDonnell Aircraft Corp. in St. Louis.

The tunnel—called the "hot shot" by its McDonnell designers—creates test conditions with speeds from 10 to 27 Mach at temperatures up to 14,000° F. and pressures as great as 100,000 psi. These conditions, which are similar to those encountered by a rocket or missile re-entering the earth's atmosphere from outer space, are contained in an arc chamber fabricated from a 9300-lb. forging of VascoJet 1000. The forging, largest ever made of the ultra-high strength steel at the time, was produced by Ladish Co., Cudahy, Wis., who air hardened, tempered and rough machined the large steel section to approximately 36 in. in diameter, with a length of 42 in. and a 12-in. cavity for the cartridge, also made from the same high-strength steel. McDonnell later finish machined the components at Lambert Field.

The steel was selected for these critical parts after an extensive testing program proved it easily reached the required ultimate tensile strength of 22,000 psi. despite the exceptionally large sizes involved.

McDonnell Aircraft, a fabricator of the Mercury Space Capsule designed to loft man on his first trip into outer space, built the "hot shot" to explore the aero and thermodynamic factors of high-speed flight. The supersonic speeds are reached by discharging a 7,000,000 joule, lightning-like charge, equivalent to the combined impulse power of the Grand Coulee and Hoover Dams, into the sealed VascoJet 1000 arc chamber. A specific mass of air in the chamber is instantaneously superheated by the charge, sending a searing blast through a tungsten throat into the 30 or 50-in. diameter test sections.

The new Hypervelocity Impulse Tunnel, financed entirely by McDonnell, will provide an important key for study of aero-thermodynamic problems encountered during design of manned and unmanned rockets and missiles, not only by McDonnell, but by others in the industry having need for use of such facilities for solution of their problems.

METAL PLATE SHEDS LIGHT—One of the first examples of electro-luminescent lighting devices is this night-light switch plate made for use in the home. Produced by Sylvania Electric Products, Inc., the switch plate contains a Panelescent lamp that produces enough light to be visible through the white plastics covering on the lamp. When a switch is turned off, the lamp glows. When the switch is turned on, the lamp goes off. Light in the device over the entire surface of a metal panel is created through the excitation of certain phosphors in an electrical field. Only 0.025-in. thick, the lamp is made of a porcelainized steel sheet with a ceramic-phosphor coating.

PARTS & FORMS

Produces Strong Missile Cases

Stronger, more reliable motor cases for guided missiles now can be produced by a new metalworking capability, cold deep drawing, it was reported by ACF Industries, Inc.

The process, according to Donald B. Howard, staff metallurgist in the company's American Car and Foundry Division, is "an advance in the state of the art of drawing metal and results in extra-strong cases that can be used either for solid or liquid-propelled missiles". He added that ACF had proved its new process by successfully drawing chamber components for the second-stage Polaris missile advance test program.

Result of the process is a one-weld case that consists of two halves butt-welded to form a motor chamber. Weight and size can vary, but the prototype weighed approximately 250 lb. and was about 54 in. in diameter at the welded seam. Depth of each half exceeded 38 in.

According to Howard, the advantage of using the new process is the elimination of two seams found on rolled and welded cases. The rolled and welded method produces a cylinder rolled from a flat sheet of metal which then is longitudinally welded and has a head welded at each end.

He said that a number of factors are responsible for ACF's being "the only company ever to have accomplished deep drawing an item of

such size". These factors include a 4000-ton press at the company's Milton, Pa., plant, a unique process for surface treating the metal and the availability of special close-tolerance high-strength alloy wide steel sheet from which the cases are cold formed.

The seven-stage treating process is carried out in a phos-lube dip tank line which is the largest in the world. The workpiece is process-annealed and completely treated between each drawing step with a phosphate film that acts as a host for lubricants, which, in turn, prevent metal-to-metal contact of the workpiece and the dies during the cold forming process.

The steel composition is specially developed to respond to heat treatment in excess of 210,000 psi. yield after cold forming. Sheet circles used by ACF are 108 in. in diameter and 0.080 in. thick.

The sheet is prepared by a sandwich rolling technique for thickness control that consists of a pack of four or more layers of steel plate, with a chemical separator between each, that is sealed at the edges by welding. The resultant 120-in. square sheets are then spheroidize-annealed while still in the sandwich to achieve uniform mechanical properties. The outer cover sheets and edging then are discarded and the sheet product is shipped to ACF.

Manufacturing Steps

At ACF's Milton plant, the deep-drawing process is carried out in the following steps:

—A simple straight draw from the flat sheet results in a shallow cup 12 in. deep and 85 in. in diameter.

—An initial reduction draw from the first cup results in one that is 15 in. deep and 76 in. in diameter.

—A second reduction draw extends the depth to 20 in.; the diameter to 68 in.

—A final reduction draw results in a depth exceeding 38 in. and a diameter of approximately 54 in.

Howard said that the most critical part of the entire operation is "keeping thickness and hardness uniform". He said an electronic micrometer checks thickness throughout the process to assure that the demanding tolerance of plus or minus 0.010 in. is achieved.

Computers Predict Quality of Metal Castings

Digital computers can now be used to eliminate trial-and-error experiments in predicting the quality of metal castings, according to scientists at Battelle Memorial Institute, Columbus.

Battelle nuclear metallurgist Ellis Foster and systems engineer B. L. Fletcher propose that the metallurgist reconsider his problems in heat transfer in light of the capabilities of modern digital computers and the developments in computer programming and numerical analysis techniques.

The key to computer analysis of castings is a method of accurately predicting the patterns of heat removal from a solidifying casting. With this established, almost every variable of the casting process can be evaluated on the basis of its effect on solidification and soundness of the ingot.

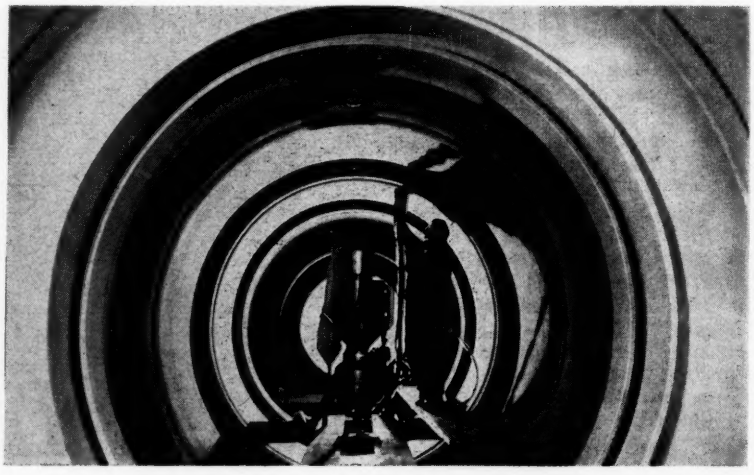
The first step in studying casting problems by computer is to describe the physical situation in terms of a mathematical model which can be used to predict the thermal history of a casting under specified conditions. Once the computed predictions have been checked by experimental work, the mathematical model can then be used to predict the effects of altered casting procedures or shapes without further experimentation.

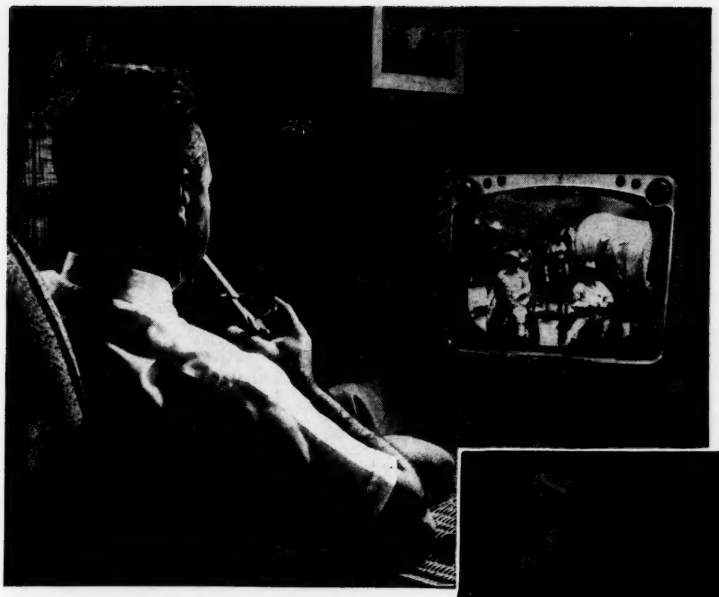
Computer analysis is especially valuable for intrinsically expensive metals like uranium and for metals like columbium and molybdenum which are easily affected by defects in the castings, the Battelle authors observe.

This analytical technique could also be applied to continuous casting, where it is inconvenient to vary conditions experimentally because of the large-scale operation; to developing specifications for shapes and sizes of risers by evaluating mold materials, pouring temperatures and metal properties; and to heat treating by evaluating how long and at what temperature metal should be kept in furnaces or baths to achieve a desired result.

Fabrication processes also have characteristics that can be studied by the techniques described by Foster and Fletcher. For example, the temperature attained by a forging is the product of the metal properties, the energy imparted in forming, the metal's initial temperature, and the heat losses by conduction, convection and radiation. The mechanical properties also vary with temperature and the ability of a material to be formed may lie within a certain temperature range.

CLEANER THAN CLEAN—The interior of this 52-ft. 6-in. long stainless steel vessel is being sand blasted by W. E. Moore, an employee of Struthers Wells Corp., manufacturer of the vessel. About 22 tons of Type 304 stainless steel plate is used for each vessel which is destined to store liquid oxygen at one of America's missile defense bases. The sanding operation of the first of many steps required to make the interior immaculately clean before it is sealed. Before final acceptance, each vessel must undergo a microscopic, a white filter paper and a black light examination. After sand blasting, the vessel interior is vacuum cleaned, washed with acid, then with detergent and water and finally rinsed several times with water having less than 10 parts per million total solids, suspended or dissolved. (Photo courtesy Allegheny Ludlum Steel Corp.)





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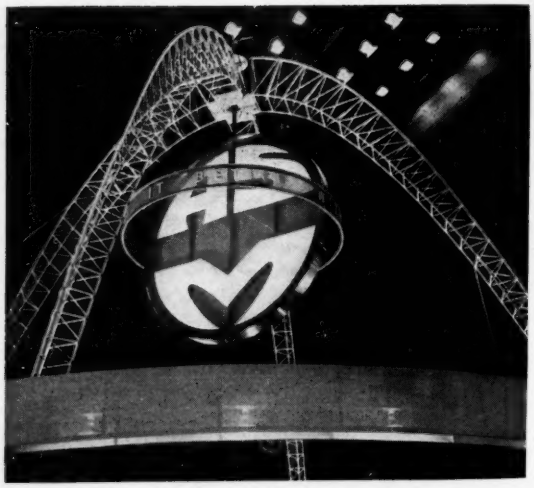

SETTING THE THEME — *Unusual "space frame" theme tower in the Metal Show Steel Arena proclaimed "Build It Better With America's Steel". Exhibits of 18 steel companies were grouped around the all-steel theme tower, together with educational exhibits of the American Society for Metals.*

shaped itself towards a metalworking personality—this, added Putnam, at a sacrifice of 20,000 sq. ft. of exhibit space occupied in the 1959 Metal Show by exhibitors not directly concerned with basic materials and processes of metalworking.

The objective of the American Society for Metals in creating 11 product categories for Metal Show exhibitors, according to Putnam, is to give the industry a concentrated opportunity for presenting its ideas under "laboratory" conditions. He expects the categories, each with a unique and descriptive symbol, to become industry-wide definitions of "what is metalworking".

In shaping its exhibitor content, A.S.M. has in the process shaped the Metal Show audience. The 1960 Metal Show visitors represent men who are interested in metalworking as defined in the 11 categories. The attendance, like the exhibits themselves, was a concentrated cross-section of metalworking.

Putnam reported this was the most talked about Metal Show in years. The most heard comment was "A.S.M. really meant what they promised—a *Metal* Show". And since a record is something not to stand on but to build on, the 1961 Detroit Metal Show will see further refinement and enlargement in the metalworking image.

About 92% of the firms who exhibited in Philadelphia, he said, already have indicated a desire to

PHILADELPHIA—

SHOWCASE OF MATERIALS AND PROCESSES

PHILADELPHIA—Members of American Society for Metals and others in the metalworking industry who attended the 1960 Metal Show still are talking about the Society's efforts to provide metalworking with an educational showcase of its knowledge in materials and processes technology.

Allan Ray Putnam, A.S.M. managing director, echoed the consensus of exhibitors and visitors by referring to this year's Metal Show as an educational shot-in-the-arm for a consolidated metalworking industry, and one that will have far-reaching effects in the business of keeping America competitive.

Metalworking, he said, showed in Philadelphia that it knows how to communicate its ideas by utilizing its vast knowledge of technology. For example, hundreds of technical and marketing experts were kept busy in the exhibits answering questions to help the industry meet competition.

He pointed also to the fact that the industry was able to take full advantage of special educational features like the Metal Show's Steel Arena to get across its important story. Most important, he concluded, was the industry's united effort to present itself as the fast-moving, highly competitive keystone of the nation's economy it is.

The 1960 Metal Show, according to Putnam, displayed some striking differences—not only from past Metal Shows, but from other expositions as well. For the first time, the show that has served the metalworking industry for 42 years defined its base and exhibit in the 1961 Detroit Metal Show and the A.S.M. Materials Comparison Center, scheduled for Oct. 23-27 in Cobo Hall.

TALK WITH THESE EXPERTS—*A feature of the 1960 Metal Show was the emphasis placed on qualified technical personnel in the exhibits, demonstrating new advances, answering specific questions, helping to solve metalworking problems.*

A. S. M. METALLOGRAPHIC AWARDS—1960

Class 1—Iron and Steel, Cast and Wrought

Best in Class: Gordon C. Woodside (See Best in Exhibit Box).

Honorable Mention: Stephen A. Oliver, Massachusetts Institute of Technology, West Newton, Mass.—Transverse Section of Swaged Iron Wire.

Honorable Mention: Mrs. T. V. Brassard, Research Laboratory, General Electric Co., Schenectady, N.Y.—Alloy of Fe, 5% Mn, 1% C Showing High-Temperature Pearlite Nodules Growing With Increasing Interlamellar Spacing and Nucleating From a Pro-Eutectoid Carbide Plate.

Class 2—Stainless Heat Resisting Alloys

Best in Class: Charles H. Monroe, Detroit Testing Laboratory, Inc., Detroit—Sensitized Wires in Composite Stainless Filter Screen.

Honorable Mention: William R. Presnell, Research Dept., Caterpillar Tractor Co., Peoria, Ill.—Super Eatonite Valve Facing.

Honorable Mention: J. Bressanelli and F. Baureis, Central Research Laboratory, Crucible Steel Co. of America, Pittsburgh—Pinning of a Grain Boundary in Type 430 Titanium-Bearing Stainless.

Class 3—Aluminum, Magnesium, Beryllium, Titanium and Their Alloys

Best in Class: D. Stiles, M. Stratis and W. Hughes, Westinghouse Research Laboratories, Pittsburgh—Aluminum-Silicon Eutectic in 88% Al, 12% Si Alloy.

Honorable Mention: James R. Dvorak, Metallographer, Armour Research Foundation, Chicago—Alpha Solid Solution Plus TiO in Titanium Alloy With 30% ZrO_2.

Class 4—Copper, Lead, Zinc, Nickel and Their Alloys

Best in Class: Robert F. Dragen, Metallographer, Armour Research Foundation, Chicago—Two Phases, YCu_4 and YC_6, in Copper Alloy With 22% Yttrium.

Class 5—Metals Used in Atomic Reactors (Zr, Th, U, Pu, etc.)

Best in Class: Clifford W. Price, Metallurgy Division, Denver Research Institute, Denver, Colo.—Deformation Bands in Epsilon Phase of Zirconium-Hydrogen System as Revealed by Polarized Light.

Honorable Mention: A. D. McMaster, Knolls Atomic Power Laboratory, General Electric Co., Schenectady, N.Y.—Zirconium With 10 at.% Columbium as Beta Quenched From 900° C.

Best in Exhibit

Gordon C. Woodside
Climax Molybdenum Co. of Michigan, Detroit

Section of "Heated Checked" Unalloyed Gray Iron Permanent Mold

Class 6—Metals and Alloys Not Otherwise Classified

Best in Class: J. Nelson and R. Johnson, Westinghouse Electric Corp., East Pittsburgh, Pa.—Dual Dendrites Co-Existing in Eutectic Matrix of a Tellurium-Silver-Antimony Alloy.

Honorable Mention: W. A. Roman, Research Laboratory, General Electric Co., Schenectady, N.Y.—Segregation in Cast Alnico.

Class 7—Series Showing Transitions and Changes During Processing

Best in Class: R. R. Russell, Research Laboratory, General Electric Co., Schenectady, N.Y.—Pearlite Reaction in High-Alloy Steel.

Class 8—Welds and Other Joining Methods

Best in Class: Henry V. Konjevich, Metallographer, Armour Research Foundation, Chicago—Iron-Boron Interface Between High-Carbon Steel and Molybdenum Composite Heated to 2150° F. for 10 min. in a High Vacuum.

Honorable Mention: R. Reinhart and G. Rolfe, Thompson-Ramo-Wooldridge, Valve Division, Cleveland—Structural Composite of Modern Aircraft Exhaust Valve Depicting Weld Junctions of Seat Face, Dome and Tip.

Class 9—Surface Coatings and Surface Phenomena

Honorable Mention: James C. Wilkins, Armco Steel Corp., Middletown, Ohio—Typical Microstructures of Aluminized Steel.

Class 10—Slags, Inclusions, Refractories, Oxides, Cermets and Aggregates

Best in Class: Frank Duce, General Electric Co., Schenectady, N.Y.—Nonmetallic Inclusion and Ferrite Stringers in As-Cast 12% Cr Steel.

Class 11—Electron Micrographs by Replica Techniques

Best in Class: A. A. Kapusta, General Electric Co., Schenectady, N.Y.—Million-Mesh Grid—Sheet of (Mo, Ti) C Precipitated in G.B. of an Fe, Co, Ni-Base Alloy Aged 1000 Hr. at 1600° F.

Honorable Mention: A. S. Holik, Research Laboratory, General Electric Co., Schenectady, N.Y.—Fracture Surface of Polygonized Sapphire Showing Cleavage Step Formation.

Class 12—Transmission Electron Micrographs

Best in Class: A. Szirmae, U. S. Steel Corp., Fundamental Research Laboratory, Monroeville, Pa.—Pearlite in a Low-Alloy Steel—Dislocations Between Cementite Plates and at Cementite-Ferrite Interface.

Honorable Mention: G. Thomas and M. C. Huffstutler, Jr., Minerals Research Laboratory, University of California, Berkeley—Structures in Aluminum-Magnesium-Zinc Alloy.

Class 13—Color Micrographs

Best in Class: K. H. Thomas, Hanford Laboratories Operation, General Electric Co., Richland, Wash.—Reaction of Liquid AlSi With Aluminum and Uranium.

Honorable Mention: E. S. Clarke and W. F. McAndrew, United Shoe Machinery Corp., Research Division, Beverly, Mass.—Complex Cubic Carbides of Three-Element Composition (Co, Cr, W) in Stellite.

Class 14—Results by Unconventional Techniques

Best in Class: Yuzo Yashiro, Nagoya Institute of Technology, Nagoya, Japan, and Takeo Fukutomi, Gifu University, Gifu, Japan—Thermo-Electric Image of Nickel Ribbon Showing Slip Bands and Window.

Honorable Mention: R. R. Russell, General Electric Co., Research Laboratory, Schenectady, N.Y.—Micro Tensile Test of an Aluminum Oxide Whisker at 2000° C.

Multiple Tempering Key To 300,000 PSI-Steels

ALLOY STEELS HAVE BEEN DEVELOPED with yield strength levels up to 300,000 psi. and a high degree of notch toughness capable of operating at temperatures up to 900°F. for extended periods of time, according to John C. Hamaker, Jr., director of research and metallurgical engineering, Vanadium Alloys Steel Co., speaking before the Beaver Valley Chapter. Success of the development is attributed to the ability of these materials to react to multiple tempering, thereby eliminating all remaining traces of retained austenite. The steels have led to new concepts in aircraft and missile design, with many applications remaining unexplored.

A study of the ductility behavior of the various types of steels by several methods indicated that this property was a function of yield strength level and did not appear related to chemical composition of the material. A definite correlation also was noted between notch severity and the energy required for crack propagation.

The rapid advance in metallurgical requirements for aircraft and missiles dictates that steels of still higher yield strength levels without appreciable sacrifice in ductility be developed. Avenues of approach include vacuum melting of higher alloy steels to offset loss in ductility; ausforming, which involves plastic deformation of austenite between the pearlite and martensite transformation bands, followed by transformation to martensite. Results, thus far, have indicated 40 to 60% gain in yield strength with high ductility and notch toughness characteristics, attributed to the refinement of the martensite grain achieved by the process.

Saturn Rocket to Play Key Role in Manned Satellites

THE SATURN ROCKET, which will probably play an important role in putting men into space, was described in a talk on "Satellites" given by Cary H. Rutland in Atlanta. Mr. Rutland is assistant to director of Future Projects Office, Marshall Space Flight Center, Huntsville, Ala. This newly formed organization basically assumed the space function of the A.B.M.A. (Army Ballistic Missiles Agency) and has as its primary mission the development of boosters for space vehicles.

The space vehicle booster of primary importance now is the Saturn. The Saturn is presently being designed and tested with a target of less than one year for launching of the first test article. The vehicle to be launched in the first test will be a dummy except for the first stage. At each successive launching one additional live stage will be added.

An equally important project, probably more important to the first space man, is the perfection of a method for returning a man to earth. This will probably be a accomplished by using a nose cone propelled in such a manner as to be slowed down on re-entry into the earth's atmosphere, then parachute to earth. This project, referred to as the "Mercury", will utilize a proven missile, the Atlas.

After perfection of the Saturn Rocket and of a means of returning a manned vehicle to earth, the U. S. will be in a position to put men into space. One of the first missions of men in space will be to circle the moon, get a close look at the other side, then return to earth. Next, landing a man on the moon, relaunching and returning to earth is to be accomplished.

The most impressive project planned for men in space is orbiting a manned space laboratory. This laboratory is to be manned by two or three people. Transportation to and from the laboratory is planned by use of a nose cone powered by the Saturn.

Another interesting project planned for the Saturn Rocket is placing into orbit around the earth three satellites. These satellites will be placed such that they rotate identically with the earth and, therefore, remain at the same point over the earth. These satellites will be especially beneficial in world-wide communication, navigation and weather prediction.

Mr. Rutland illustrated design details of the Saturn booster and upper stages and several of the space vehicles planned for use with the Saturn with slides and a movie. *(Reported by H. S. Pearson.)*

Nondestructive Testing Methods Described and Explained

MAGNETIC PARTICLE AND penetrant types of nondestructive testing were discussed by Carl Betz, vice-president, Magnaflux Corp., before the Syracuse Chapter.

Mr. Betz showed diagrams describing the detection of flaws when the lines of force were perpendicular to the flaw. Detection is not possible when the lines of force are parallel to the flaw. A new approach to this particular problem is to magnetize in two or more directions by rapidly switching alternating fields.

The penetrant method of nondestructive testing is as simple as the magnetic and is used in detecting flaws with surface openings. Mr. Betz described how this method is used. Trends in the nondestructive testing fields are as follows . . . (1) To increase sensitivity for small defects; (2) to increase speed, which includes more efficient means for less money; (3) dependability; and (4) elimination of the human factor (this particular one goes hand-in-hand with the speed and dependability); (5) development of standards of acceptance or rejection *(Reported by T. T. Phipps.)*

DOME DESIGNER AT DEDICATION—*R. Buckminster Fuller, above, originator of the geodesic dome principle, poses during dedication ceremonies at the base of one of five pylons supporting A.S.M.'s spectacular dome. Shown at the base of the pylon is a dedicating plaque provided by Ampco Metal Co., Milwaukee, Wisc.*

URANIUM CAPSULE DONATED—*Allan Ray Putnam, A.S.M. managing director, accepts an anodized aluminum capsule containing a one-lb. piece of uranium metal from J. S. Skogland (left) and John Fellows (right), chairman and vice-chairman, respectively, of the St. Louis A.S.M. chapter. The uranium metal was provided by Mallinckrodt Chemical Works and the capsule by the St. Louis chapter.*

Ceremonies Mark Official Dedication of A.S.M. Headquarters

On Wednesday, Sept. 14, the American Society for Metals dedicated its geodesic-domed national headquarters in Geauga County, near Cleveland. Several hundred important leaders from industry, government and scientific circles were in attendance. Many A.S.M. chapters were represented by officers and members.

Highlights of the event were dedication addresses by Clyde Williams and Zay Jeffries, and placement of a time capsule containing nearly a pound of uranium metal. Walter Crafts, A.S.M. national president, presided throughout the ceremonies, and presented the building to Allan Ray Putnam, managing director, for "increased dissemination of technical information for constantly improving technology in metalworking".

Dr. Williams, one of the nation's outstanding administrators of science and research, cited the technical society as the "essential link" between science and industry which can do much to meet the threat of Russia, the "corrupter of the spirit of science". Former president and director of Battelle Memorial Institute, Columbus, Ohio, he is now president of his own management consulting firm in that city.

The "Dean of American Metallurgists", Dr. Zay Jeffries, paid tribute to late A.S.M. founder-member, W. H. Eisenman, by calling for positive steps in fighting the present war with Russia—"cold" war or whatever—by utilizing every technological means at our disposal. He spelled out specific steps that the A.S.M. can take to help *win* the cold war from Russia.

At the conclusion of his address, Dr. Jeffries unveiled a bronze bust of Mr. Eisenman, who had conceived a dramatic building of metals, for A.S.M. national headquarters, and donated the

100 acres on which it stands. Dr. Jeffries, former Case Institute of Technology professor and later head of General Electric's Carboloy subsidiary and chemical department, is now a consultant in Pittsfield, Mass. He founded the Cleveland Chapter A.S.M.

Feature of the dedication ceremonies was a time capsule containing nearly a pound of highly radioactive uranium metal. Many documents, books and other materials of the American Society for Metals are included to provide metalworking of a future era with a running account of the progress made up to 1960.

The uranium is encased in a gold anodized, en-

(*Continued on page* 24)

graved aluminum capsule donated by the Society's St. Louis Chapter. The uranium itself was provided by Mallinckrodt Chemical Works, Uranium Div., St. Charles, Ill. The uranium and capsule were the results of efforts by J. S. Skogland and John Fellows, chairman and vice-chairman, respectively, of the St. Louis Chapter.

A Geiger counter, provided by Victoreen Instrument Co., Cleveland, will detect the presence of the A.S.M. Time Capsule, placed in the entrance plaza at the base of one of the five supporting pylons of the geodesic dome. The counter's steady "tick-tick-tick" over the years will be a constant reminder of the Society's efforts in 1960 to record the best of today's engineering for comparison with tomorrow's.

Requirements of Space Age Materials Are Described

The ideal material for many space age applications would have high strength at elevated temperatures plus corrosion resistance and impact properties for underwater use, according to M. E. Taylor, supervisor of mill processing section, Crucible Steel Co. of America, speaking before the Rocky Mountain Chapter in Denver.

Titanium alloys come closest to filling both requirements, but unfortunately suffer too much loss of strength above 1000°F. The various grades of special stainless steels, according to Mr. Taylor, are being used in increasing proportions. Molybdenum, titanium and boron are added to the chromium-nickel alloys to extend their usefulness to higher temperatures.

The speaker reported that vacuum melting of the various alloys has a marked effect in improving physical and mechanical properties, especially in the precipitation hardening grades. Vacuum melting lowers gas content, reduces nonmetallic inclusions and eliminates hot shortness. Porosity and shrinkage troubles are also eliminated.

Other materials being considered for high-temperature service include tantalum, tungsten and rhenium which give excellent results but which are expensive. *(Reported by W. B. Leaf)*

Ottawa Hears Talk on Aerial Surveys

MEMBERS OF THE OTTAWA VALLEY CHAPTER had the opportunity to hear guest speaker, John Roberts, technical director of Spartan Air Services Ltd., at sustaining membership's night.

Mr. Roberts, a well-known figure in Canadian commercial aviation, with a wealth of experience in aerial surveying, spoke on "Developments in Aerial Surveying". He discussed the improvements in equipment and techniques in recent years and commented on the important role played by aerial surveying in the utilization of natural resources, particularly in the discovery and development of mineral and oil deposits.

Chapter Chairman Neville Spence notified the members of the aims of PIC (Project: Industry Coverage) and introduced Dave Fleck, the chairman of the membership committee, who pledged his support to this project. Roger McDonald, educational lecture committee chairman, gave details of the 1960 Educational Lecture Series which will cover "Basic Ferrous Metallurgy" and a Past-Chairman's Certificate was presented to John Edwards.

The Chapter welcomed their new Sustaining Members and certificates were presented to: Aluminum Co. of Canada Ltd., University of Ottawa and Carleton University. *(Reported by C. Dixon.)*

METAL PROGRESS EDITOR HONORED—*E. E. Thum, editor-in-chief of* Metal Progress, *was surprised during a recent meeting at Metals Park by being presented this certificate of appreciation. The certificate attested to Thum's four years of service as chairman of the Advisory Committee on Industrial Information to the United States Atomic Energy Commission. Making the presentation is Morse Salisbury, director of Information Services, A.E.C., while Allan Ray Putnam looks on.*

Two Speakers Appear Before Carolinas Chapter Meeting

THE CAROLINAS CHAPTER featured talks by Roland F. Beagle, superintendent, Ronson Hydraulic Units Corp., Charlotte, and J. S. Kirkpatrick, vice-president, Brooks and Perkins Corp., Detroit.

Mr. Beagle, speaking on "Training of Personnel in Uses of Metals", emphasized the quality of workmanship required in our modern apparatus. He repeatedly stressed the fact that reliability is a function of materials, dimensional tolerances and very fine finishes, and the training of personnel (both supervisory and operating) necessary to produce them. According to Mr. Beagle, elementary training in basic machine tools is only a beginning and more advanced training is needed. In answer to a question from the floor Mr. Beagle stated that while all companies do train some personnel for special jobs and many industries need trained men in this area, there is no formal apprentice program offered to the best of his knowledge.

Mr. Kirkpatrick, speaking on "Materials of the Space Age" gave an informative and interesting slide lecture covering the exotic materials used in our present supersonic aircraft and space vehicles. He covered some of the problems imposed by such unusual materials as beryllium, titanium, boral, zirconium and magnesium. Mr. Kirkpatrick pointed out the fact that guns, as aircraft armament, were made obsolete by the supersonic speeds of these vehicles and thus we have been catapulted into the age of guided missiles. Most of the materials used in space vehicles or satellites is of the light metal variety but far greater volumes of some of these metals are used in products for everyday use. Among the specific examples cited by Mr. Kirkpatrick were the 40 lb. of magnesium in each Volkswagen engine, magnesium truck bodies and cabinets, magnesium printing plates and magnesium shaft couplings. To use Mr. Kirkpatrick's words, "While these are the materials of the future, they should be considered by today's designer wherever weight or inertia are a problem". *(Reported by O. J. Fischer.)*

Army's First Reactor Dedicated to H. H. Lester

THE FIRST NUCLEAR REACTOR to be provided for the Army was dedicated, on May 17, 1960, to the memory of Horace Hardy Lester, in a ceremony held at Watertown Arsenal, Watertown, Mass. Built at a cost of more than a million dollars, the reactor will be used by the Army for materials research.

Dr. Lester, a long-time active member of the Boston Chapter, was chief scientist at the arsenal from 1922 to 1953, and consultant, Ordnance Materials Research Office, from 1953 until his death in 1955. He was nationally recognized as a pioneer in the field of industrial radiography and contributed a lifetime of effort to the establishment and growth of basic research at Watertown Arsenal. He initiated and promoted the nuclear reactor project.

Metals Terminology

Selected Definitions from the Forthcoming 8th Edition of the A.S.M. Metals Handbook

Annealing—Heating to and holding at a suitable temperature, and then cooling at a suitable rate, for such purposes as reducing hardness, improving machinability, facilitating cold working, producing a desired microstructure, or obtaining desired mechanical, physical or other properties.

When applied to ferrous alloys, the term "annealing", without qualification, implies full annealing.

When applied to nonferrous alloys, the term "annealing" implies a heat treatment designed to soften a cold worked structure by recrystallization or subsequent grain growth or to soften an age-hardened alloy by causing a nearly complete precipitation of the second phase in relatively coarse form.

Any process of annealing will usually reduce stresses, but if the treatment is applied for the sole purpose of such relief, it should be designated stress relieving.

Bronze—A copper-rich copper-tin alloy with or without small proportions of other elements such as zinc and phosphorus. By extension, certain copper-base alloys containing considerably less tin than other alloying elements, such as manganese bronze (copper-zinc plus manganese, tin and iron) and leaded tin bronze (copper-lead plus tin and sometimes zinc). Also, certain other essentially binary copper-base alloys containing no tin, such as aluminum bronze (copper-aluminum), silicon bronze (copper-silicon) and beryllium bronze (copper-beryllium). Also, trade designations for certain specific copper-base alloys, such as architectural bronze (57% Cu, 40% Zn, 3% Pb) and commercial bronze (90% Cu, 10% Zn).

Deoxidizing—(1) The removal of oxygen from molten metals by use of suitable deoxidizers. (2) Sometimes refers to the removal of undesirable elements other than oxygen by the introduction of elements or compounds that readily react with them. (3) In metal finishing, the removal of oxide films from metal surfaces by chemical or electrochemical reaction.

Ferroalloy—An alloy of iron that contains a sufficient amount of one or more other chemical elements to be useful as an agent for introducing these elements into molten metal, usually steel.

Zone Melting—Highly localized melting, usually by induction heating, of a small volume of an otherwise solid piece. By moving the induction coil along the rod, the melted zone can be transferred from one end to the other. In a binary mixture where there is a large difference in composition on the liquidus and solidus lines, a high degree of purity can be attained by concentrating one of the constituents in the liquid as it moves along the rod.

Explosive Forming Shapes Unworkable Metals

THE NEED FOR LIGHTER, stronger and tougher metal fabrications to meet present-day performance requirements has made many engineers desirous of using alloys sometimes classified as unworkable. Conventional methods of shaping such materials into intricate parts which must adhere to rigid dimensional tolerances are proving unsatisfactory in an ever increasing number of instances. To overcome this barrier, much exploratory work has been conducted within the last decade to develop a new process called "explosive forming". Although the first patents were taken out in 1898, the process lay dormant until recently when the economic situation made it more feasible.

At a Tri-City Chapter meeting, Earl K. White, Sr., American Potash and Chemical Corp., defined explosive forming as a means of shaping metals from the pressure or shock created by the gases of a chemical explosion. The pressure is transmitted through air or other chosen medium to the metal stock, which, being transformed through a plastic stage in a matter of micro-seconds, assumes the shape of a forming die. It is not yet fully understood what physical changes occur in metals submitted to explosive shock action; however, the process has the inherent characteristic of keeping springback, which is sometimes troublesome in metal forming, at a minimum. Dimensional tolerances of 0.002 in. can be achieved, enabling forming dies to be made the exact size of the part to be formed.

Explosive forming is essentially divided into two areas, namely: Bulge-type forming carried out in closed dies with low explosives; and sizing carried out in open dies with high explosives. Features of both methods can be combined upon occasion. With either method the shape of the explosive charge is important, because shock waves moving out parallel to the face of the charge are greater than those moving out at angles. This characteristic has proven helpful in contour forming the more complex shapes.

One of the first successful practical applications for explosive forming occurred about six years ago. A Navy rocket nozzle, which could not be formed by conventional methods, was formed by flaring a 10-in. low-carbon seamless tube to 17 in. Such elongation had never before been achieved. Further applications have been the forming of stainless steel sound suppressor tubes for the Boeing 707 jets, among other aircraft parts, and the forming of "frogs" used in railroad switching. Life expectancy was increased threefold in the case of the railroad frogs. Apparently there are few limitations as to the size of the parts formed. One stainless steel part weighing 5000 lb. and having a 4 to 5 in. wall thickness is reported to have been formed successfully. Explosives are also being used to bond dissimilar metals. Some bonds which have been achieved are copper to steel and titanium and aluminum to stainless steel. Compaction of metal powders is also being investigated.

Explosive forming is not intended to replace the current methods of pressing, cupping, drawing, extruding, dimpling or swaging. Rather, it is intended to supplement them. The primary advantage of the process lies in the fact that a high and controlled rate of application of forces can be obtained to aid in forming the newer and tougher alloys. Much research and development work lies ahead before the full potential and capabilities of the new process are realized.

Statistics Help Solve Metallurgical Problems

"STATISTICAL SOLUTIONS OF METALLURGICAL Problems" was the subject of a technical talk presented before the Peoria Chapter by Ralph F. Huth, technical coordinator of engineering, Operational and Statistical Application, United States Steel Co. After defining statistics as a science on which to make judgements by using numbers, Mr. Huth stated that statistics are also a means to general solutions of problems not necessarily metallic in nature.

Mr. Huth used two types of examples in the main portion of his lecture, both based on statistical work at United States Steel Co. The first dealt with factorial sorting based on measured data, such as speed of travel, which might have different values from a maximum to a minimum.

The second dealt with factorial sorting based on attribute data, such as a grade of material which may be of one or another type. Mr. Huth suggested that a factorial sorting based on measured data may be a simpler approach requiring less data than an attribute sorting approach.

Throughout his lecture Mr. Huth used descriptive slides to amplify his talk, the slides showing many of the mathematical terminology in chart form.

The discussion was concluded with a question and answer period during which Mr. Huth was asked specific questions about statistical terminology and various points of his lecture. *(Reported by Robert C. Dryden.)*

Metallurgical Engineering Up at Colorado School of Mines

Despite an approximately identical over-all enrollment this semester, the Colorado School of Mines, Golden, reports a 19% increase in metallurgical engineering students. Enrolled in this option are 243 men as compared to 198 last year.

CHAPTER MEETING CALENDAR

Birmingham	**Dec. 6**		**D. J. Snyder**	**Welding Problems in Steel Fabrication and Their Solutions**
Buffalo	**Dec. 8**		**John C. Hamaker**	New Developments in Toolsteels
Cedar Rapids	**Dec. 12**	Roosevelt Hotel		Family Night
Chicago	**Dec. 12**	Furniture Mart		Christmas Party
Chicago-Western	**Dec. 12**	Furniture Mart		Christmas Party
Cleveland	**Dec. 5**		**Panel**	Surface Treatment for Wear
Columbus	**Dec. 7**	Nationwide Inn	**R. C. McMaster**	Weather
Mahoning Valley	**Dec. 13**	Mural Room	**Bruce E. Brennan**	Aluminum
Milwaukee	**Dec. 6**	Astor Hotel	**Panel**	New Materials From Research
Mohawk Valley	**Dec. 5**		**Vincent Schaefer**	Adventures in the Atmosphere
Muncie	**Dec. 13**		**Keith Ross**	Quality Control
New Hampshire	**Dec. 9**		**John Swift**	Metal Finishing
New Jersey	**Dec. 12**			Annual Smoker and Christmas Party
New York	**Dec. 5**	New Yorker Hotel	**J. D. Peebles**	Automobile Gas Turbines
Notre Dame	**Dec. 14**		**E. H. Hollingsworth**	Physical Metallurgy and Metallography of Aluminum and Its Alloys
Ontario	**Dec. 2**	Prince George Hotel	**R. Smallman-Tew**	Aluminum Alloy Hand Forgings 7079
Peoria	**Dec. 12**		**Bruce McArthur**	Induction Heating for Hot Forming
Philadelphia	**Dec. 9**	Penn Sherwood Hotel		Christmas Party
Phoenix	**Dec. 20**		**Roy Jordon**	Computers: Past, Present and Future
Rocky Mountain	**Dec. 16**	Oxford Hotel	**Eugene V. Kleber**	16 New Metals—the Rare Earths
St. Louis	**Dec. 3**	Statler-Hilton Hotel		Christmas Dinner Dance
Syracuse	**Dec. 6**	Onondaga Hotel	**H. B. Osborn, Jr.**	Induction Heating
Upper Ohio Valley	**Dec. 14**			Christmas Party
Washington	**Dec. 12**	All States Restaurant	**Robert C. McMaster**	Nondestructive Testing
York	**Dec. 14**		**William M. Baldwin, Jr.**	Why Metals Bust

NATIONAL AND REGIONAL TECHNICAL MEETINGS

Western Metal Congress—Los Angeles—Mar. 20-24, 1961

Southern Metals Conference—Atlanta, Ga.—Apr. 24-26, 1961

National Metal Congress—Detroit—Oct. 23-27, 1961

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METALLURGICAL ENGINEER: Graduate. Experience in low-alloy and austenitic high-temperature alloys preferred, but will consider recent graduate. Assignment in process control laboratory of major automotive parts manufacturer. Work covers forging, cold forming, heat treating methods. $6500-9600. Cleveland area. Box 11-25.

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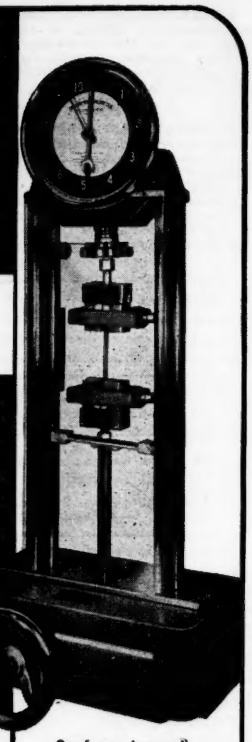

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Signature of Editor: T. C. DuMond

Sworn to and subscribed before me this 1st day of November, 1960

[Seal] Evelyn G. Gardner

(My Commission Expires Jan. 28, 1963)

POSITIONS WANTED

METALLURGIST: Indian citizen, age 29, B.S. in mathematics, M.B.A. with statistics, expecting M.S. in metallurgy June 1961. Desires suitable position in New York City area. Will relocate after completion of studies. Resume on request. Box 11-45.

FABRICATION DEVELOPMENT METALLURGIST: Desires position in Europe in "modern metals" field—nuclear, refractory or rare earth metals. Practical and diverse experience in the fabrication of hafnium, zirconium and uranium alloys, rare earth metals, ceramics and cermets. Intimate knowledge of extrusion, rolling, roll bonding, forging, swaging, turks heading and powder metallurgy processes. Resume on request. Box 11-50.

METALLURGIST: Ph.D., M.A. degrees in mining engineering, age 39, married. Would like position in foreign country. Box 11-55.

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DEVELOPMENT MANAGER OR TECHNICAL EXECUTIVE: Excellent background in research and manufacturing metallurgy covering both ferrous and nonferrous products. Expert in heat treatment, machining and fabrication practices, welding, joining, coatings, etc. Also excellent background in steel processing practices, foundry and toolsteels. Top level laboratory supervision experience. Prefers Midwest or East. Resume on request. Box 11-75.

METALLURGICAL ENGINEER: M.S. degree, age 40. Thirteen years experience in widely diversified phases of physical metallurgy, including all forms of laboratory operations, shop problems in heat treating, forming, machining, failure analysis, material selection, material and process specifications, fusion and resistance welding. Desires position with management possibilities. Box 11-80.

METALLURGICAL ENGINEER: B.S. degree, plus graduate studies. Age 28, married, three children. Six years experience in nonferrous smelting and refining, two years as superintendent of S & R department. Desires responsible position in production, development or sales. Resume on request. Box 11-85.

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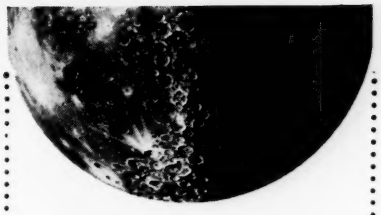

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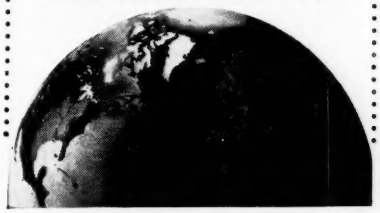

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